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DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. III.] 1892. [Part 1.

I.—Description of the Belubula Caves, Parish of Malongulli, Co. Bathurst*: By the late C. S. Wilkinson, L.S., &c., Government Geologist.

[Plates I–III.]

The Belubula Caves are on the purchased land of the old "Belubula Copper Mining Company," and are situated two miles north of the main road from Carcoar to Canowindra, eighteen miles from Carcoar, and about the same distance in a north-easterly direction from Cowra, Parish of Malongulli, Co. Bathurst.

The locality is one of much interest. High hills, with declivitous rocky spurs, descend on either side of a picturesque valley to a clear running creek, which flows with a tortuous course for about two miles, and then joins the Liscompool Creek. Some of the hills are composed of a dark porphyritic rock, an igneous rock, which, in the Devonian Period, upheaved and tilted those thick strata of limestone, whose grey rugged masses, out-cropping at the surface, form such an attractive feature in the landscape. The effect of atmospheric influences on exposed limestone rocks is here beautifully shown. The pinnacled crests and grooved surfaces of these rocks reveal in unmistakeable characters the furrowing action of rain during the present and a past age. It is amongst these strangely weathered rocks, on the side of one of the limestone spurs, not far from the creek, that the three newly-discovered caves occur.

* Extracted from the Sydney *Town and Country Journal*, Sept. 9, 1876, p. 419.

Two of the persons who found these caves accompanied me, and directed my attention first to the "Deep Cave." This consists of an almost vertical pit, the opening of which is only about three by six feet. We descended by means of a rope for forty feet, on to a ledge of rock; from this we saw that the chasm opened out to twenty feet in width and fifty feet in length, and continued to a considerable depth, as indicated by the stones which we rolled into it, but having come to the end of our rope we could not descend further. We also saw a large cavernous opening towards the south-west, leading off probably to another long, vertical pit of unknown depth, the mouth of which occurs about one hundred yards higher up the hills; into this we could not enter with the means at our disposal.

We next proceeded for about two hundred and seventy-five yards in a south-easterly direction to the "Bone Cave," the entrance to which faces towards the east, and is twenty feet wide and six feet high, but it appears originally to have been much larger. Immediately within the entrance the cave is almost blocked up with masses of rock fallen from the roof; but, by crawling over and squeezing between them, we descended about twenty-five feet, and came to a large vertical hole fifteen feet deep, hung round with ornamental stalactites; in places the sides were formed of red calcareous earth, from which numerous bones protruded (Pl. III). From the bottom of this hole we passed for six feet between walls covered with stalactites, and entered a cavern fifteen feet by twenty-four feet and ten feet high. From its roof hung beautiful stalactites, some round and pointed, and others in wavy folds like white curtains with serrated edges. Part of the floor is formed of four separate layers of stalagmite, underneath which is red earth full of fragments of bones, mingled together in a confused state. I had a large quantity of these bones collected, some of which were embedded in the hard crystalline stalagmite. On the east side is an opening nearly choked up by stalactites and red earth; it is too small to enter, but we could send stones rolling down it for a considerable distance. Not being able to go any further in this cave, we climbed up, and scrambled over the piles of rock *débris*, and returned to daylight, and proceeded to explore the "Long Cave," the mouth of which is forty-four yards south from the Bone Cave (Pl. I). Descending a perpendicular hole for six feet between craggy masses of limestone rock, we entered a passage and walked along it till we suddenly came to a small opening, which we crawled through on all-fours into a room fifteen feet wide and eight feet high. But to pass from this we had to resort to more primitive means of locomotion, by squeezing into a hole only thirteen inches high and two feet wide, and sliding down it for six feet on one's back, or on whichever side was best proof to the probing stalactites, contact with which was not always agreeable. At the foot of this incline is a thin layer of stalagmite, and through a hole broken in it we got down, and again on all-fours crawled beneath it for thirty-six feet, and then entered a long

cavern thirty-five feet high. The wall of it on the north side rises with an irregular sloping surface to the roof, and is, as it were, covered with white tracery. From the roof hang numerous stalactites, and there is one of them very fine, being upwards of six feet in diameter and eighteen feet long; it is deeply fluted and resembles the pipes in front of a large organ. From projecting ledges around the walls hang beautiful white stalactites of various lengths. They suggest the idea of petrified cascades, which in reality they are.

At the northern end this cavern branches off into two—one extending to the north-west for sixty feet, and it evidently continued further, but is now filled up with red earth full of fragments of bones; the other forms a high passage one hundred feet long, leading into a lofty and spacious chamber seventy feet in width. Here are to be seen two remarkable stalagmites eighteen inches in diameter and six feet high, they are pointed at the apex and conjoined at the base, and stand on a conical mound of stalagmite (Pl. II.) Immediately over them, and on one side, hang some beautiful curtain stalactites, descending from the roof in drapery-like folds, gracefully disposed.

When well lighted up the contrast of these white stalactites against the dark, sombre, grey limestone walls presents a very striking and weird appearance. A huge fissure extends across the roof, and probably communicated overhead with two open caverns in the surface of the hill. Out of these a strong draught of air issues, and they are doubtless the cause of the good ventilation of the main parts of the "Long Cave." From the large cavern there are seven passages branching off in various directions, and leading into other smaller chambers. In nearly all of these fresh objects of interest and attraction are exhibited. The small "Fountain Chamber" has a white floor with ornamental cavities filled with clear water from which has been formed those calcite crystals which sparkle on the sides of the cavities. In some of the caves where they have been filled with this lime water, the walls are coated with these crystals. Another small cavern, rather difficult to get into, has a mound of white stalagmite with a tracery-marked surface, meeting which, and hanging in the centre are two stalactites covered with translucent spikes curving in all directions. These singular stalactites are seen in some of the other caverns; also groups of long radiating crystals of arragonite.

We could not explore to the end of some of the passages, owing to the foul air met with, which, if we had inhaled it, would have extinguished our lives, as it immediately did our candles.

In almost all of the caverns there are two, sometimes more, layers of stalagmite both above and below which the red earth and fossil bones are found. The caves appear to have been once filled with this bone earth, which is of such a nature as

to show that it has been drifted into the caves by water, and then partly washed away again to some lower level, probably down to some of those deeper passages into which we could not enter on account of the foul air in them.

It is possible there may have been other entrances to these caves, but which are now filled up by rock *débris*, certain depressions in the surface of the hill may indicate where they existed.

The origin of these caverns is apparent. Natural joint-fissures in the limestone beds received the surface-water, which, with the aid of the carbonic acid gas contained in it, dissolved the limestone rock and in process of time these subterraneous water-courses gradually became enlarged to their present dimensions. But this took place at a period when the configuration of the surface of the land was different from what it now is. The very hills where the entrances to the caves now are, were once the bottom of valleys.

At that time the present valleys were not scooped out of the land surface, and these caverns then received the drainage. So that where is now the top of a hill a valley existed, and hills then stood where valleys now lie. But owing to the variable nature of the geological formations, the harder rocks resisted the denuding atmospheric influences, while hills of rock more readily disintegrated, had to yield to the gouging hand of time, and thus the land surface was ever changing till its present features were formed.

The miniature hills and valleys seen on those grooved, weathered, limestone rocks, before mentioned, well serve to illustrate these effects of denudation.

During these changes the original entrances to the cave have doubtless been removed, and in this way may have disappeared those places of resort which were frequented by some of the animals, whose bones were drifted into their present sepulchre.

But little surface-water can now enter these caves,—the *débris* of stones, earth and bones, appears to have been drifted in, chiefly during the Pleistocene Period.

Mr. E. Ramsay, F.L.S., Curator of the Australian Museum, has identified some of the bones as belonging to the genera *Macropus* (large Kangaroo), *Phascolomys* (Wombat), *Halmaturus* (Wallaby), and *Protemnodon*, an allied extinct genus. Several other bones may prove to be of new species.

The Belubula Caves were first explored by Messrs. T. J. Peters, T. and J. O'Shaughnessy, and A. Potts, road contractors.

I saw several depressions and holes in the limestone rocks in the vicinity, which probably lead into other subterranean chambers.

About half-a-mile in an easterly direction from the caves is the shaft of the Belubula Copper Mining Company. It has been sunk following a breccia-quartz reef, two feet thick; the quartz contains the grey sulphide and carbonates of copper sparingly distributed through it, also calcite. The reef traverses porphyritic diorite and dips S. 20° W. at 62°. It is probably auriferous.

Near the Belubula River on Mr. W. M. Rothery's Estate, and about three miles north from the Caves, there is a hot spring, from which, Mr. Rothery informed me, that a volume of water at a temperature of 88° Fahr. issues at the rate of about seven hundred gallons per minute. That it contains lime in solution is evident from the calcareous tufa deposited from it. This spring is said to have been running in the same manner ever since it was discovered, more than thirty years ago. It is, no doubt, an outlet for the water collected by some of the numerous caves in this limestone country, the water becoming heated in its passage through the rocks at considerable depths.

II.—*Hymenocaris Salteri*, M'Coy, m.s.: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plate IV.]

I.—History.

As early as 1861, Sir F. M'Coy determined a Crustacean from the Graptolite Shales of Victoria as *Hymenocaris Salteri*,* but no description was offered, the Professor contenting himself with the following remark—"The characteristic genus *Hymenocaris* of these ancient beds in Wales also occurs here in a peculiar species, *H. Salteri* (M'Coy)."

The name has appeared in print at intervals since then, but after a lapse of thirty years, I believe, it still remains a M.S. name. The second occasion on which Professor M'Coy referred to his fossil appears to have been in the Second Edition of his "Ancient and Recent Natural History of Victoria,"† and a third time in a list of Victorian fossils contributed to the "First Annual Report" of the Second Geological Survey of Victoria,‡ by the late R. Brough Smyth. By Bigsby, the species was twice catalogued in his laborious compilation "Thesaurus Siluricus,"

* The Ancient and Recent Natural History of Victoria. *Vict. Intercol. Exhib. Essays*, 1861, p. 162.
† Ann. Mag. Nat. Hist., 1867, XX, p. 201.
‡ P. 33 (r. 8vo. Melbourne, 1874).

as *Hymenocaris* and *Caryocaris*.* The latter name was, doubtless, derived from Mr. J. W. Salter, who, during the progress of the London International Exhibition of 1862, had an opportunity of examining authenticated specimens. After noticing the Victorian Llandeilo Graptolites, the latter remarked, "There is even a Crustacean, apparently of the genus *Caryocaris*, which M'Coy has done me the favour to name *Hymenocaris Salteri*.†

In reviewing this species, the British Association Committee "On the Fossil Phyllopoda of the Palæozoic Rocks" (Messrs. R. Etheridge, H. Woodward, and T. Rupert Jones) remark,‡ "The Australian *Hymenocaris Salteri*, M'Coy, having been assigned by Mr. Salter to *Caryocaris*, when he was studying that group in 1862, we have regarded it as a member of the latter genus." They further say—"Thus it is evident that Salter saw one example, if not more, of this Australian species in 1862, and did not regard it as a *Hymenocaris*." This appears to be the concensus of opinion regarding *H. Salteri* up to 1883.§

The object of the present remarks is to show that the fossil is neither a *Hymenocaris*, nor a *Caryocaris*, but is, in all probability referable to another genus of Salter's—*Lingulocaris*. I do not think the Australian Crustacean is allied to *Saccocaris*, judging by the figures given by the Committee.‖

II.—Descriptive Remarks.

Hymenocaris Salteri has never been met with, so far as I know, in any other than a filmy compressed state, quite similar to that of many *Ceratiocaris* in the Upper Silurian rocks of Britain.

Mr. W. W. Froggatt, whilst in charge of the Departmental Exhibits at the Ballaarat Juvenile Exhibition, made a collection of Graptolites from the Lower Silurian shales at Sandhurst, with a number of the filmy compressed carapaces of *H. Salteri*, and fragments of chitinous body segments. I am also indebted to Mr. R. A. F. Murray, Government Geologist of Victoria, for additional specimens from Baynton's, Campaspe River, Central Victoria.

The genus *Hymenocaris* was described by the late Mr. J. W. Salter, in 1852, as having an ample, semi-oval, very thin carapace, curved downwards at the sides, but not angularly bent along the middle line, two pairs of antennæ, and an abdomen of eight or nine segments.¶ Some years later, *Caryocaris* was described ** from the Skiddaw Slates, possessing a long, pod-shaped, bivalve carapace, with distinct hinge pits, rounded in front and sub-truncate behind, whilst the surface is smooth

* Pp. 73 and 200 (4to. London, 1868).
† Quart. Journ. Geol. Soc., 1863, XIX, p. 139, *note*.
‡ Brit. Assoc. Report for 1883 [1884], p. 215.
§ *Loc. cit.*, p. 221.
‖ *Loc. cit.* for 1890 [1891], p. 427.
¶ Brit. Assoc. Report for 1852 [1853], Part 2, p. 58.
** Quart. Journ. Geol. Soc., 1863, XIX, p. 139.

or only wrinkled. It will thus be apparent that *Caryocaris* differs from *Hymenocaris* in its angularly bent, pod-shaped, and thus definitely bivalve carapace, and not a merely arched semi-oval shield curved downwards at the sides.

Now, it will be obvious at the first glance, that in M'Coy's Victorian species the carapace is not ample and semi-oval; furthermore, in all our specimens, the dorsal edge, which is much less curved than the ventral, is always apparent as a distinct hard margin, or sharp impressed line. From these I opine that the carapace was bivalved and sharply bent rather than merely folded. As regards the ends, so far as the filmy nature of the substance will permit one to judge, one, presumedly the posterior, is truncate more or less; the other, equally supposed to be the anterior, is very obtusely pointed. Lastly, the more highly curved of the two margins, which I have assumed to be the lower, invariably shows a double line, one usually within the other, implying that they are the adpressed edges of the two valves. Accepting these facts, there appears to be presumptive evidence that the Victorian Crustacean is not *Hymenocaris*, and the outline of the carapace equally forbids a reference to *Caryocaris*, as suggested by Mr. Salter.

In 1866, Salter proposed a third genus of similar Phyllocardia, under the name of *Lingulocaris*,* with a thin bivalve shell, a generic form like that of a *Modiola*, or *Mytilus*, and the surface covered with fine raised concentric lines. The rather indefinite diagnosis assigned by Salter to his genus, has been supplemented with additional details and figures by the Fossil Phyllopoda Committee, from which it becomes apparent that the Victorian fossil is much more closely allied to *Lingulocaris* than to either of the others. The Committee figure two additional species *L. Salteriana*, and *L. siliquiformis*, with an acutely subovate or sharply boat-shaped carapace. The dorsal margin, or back, is straight, and the ventral, or front, convex. The outline of M'Coy's *Hymenocaris Salteri* is so obviously intermediate between that of these two species, and the typical characters of *Hymenocaris* and *Caryocaris* absent, that a reference of the species to *Lingulocaris* becomes necessary. As the Committee have used Mr. Salter's name in a specific sense, I am reluctantly compelled to abandon M'Coy's term, and cannot, therefore do better than adopt for the fossil in question that of *Lingulocaris M'Coyi* with the following diagnosis:—

Lingulocaris M'Coyi, *sp. nov.*

Pl. IV.

Hymenocaris Salteri, M'Coy (m.s.)—Ancient and Recent Nat. Hist. Vict. (Vict. Intercol. Exhib. Essays), 1861, p. 162.

Hymenocaris Salteri, M'Coy (m.s.)—Ann. Mag. Nat. Hist., 1867, XX, p. 201.

Hymenocaris Salteri, M'Coy (m.s.)—Smyth's 1st Ann. Report, 2nd Geol. Survey Vict., 1874, p. 33.

Caryocaris Salteri, Salter, Quart. Journ. Geol. Soc., 1863, XIX, p. 139, *note*.

Hymenocaris ? (Caryocaris) Salteri, Etheridge, Woodward, and Jones, Brit. Assoc. Report for 1883 [1884], Pl. I., p. 221.

* Mem. Geol. Survey Gt. Brit., 1866, III, p. 294.

Sp. Char.—Carapace siliquiform to boat-shaped; anterior end pointed; posterior end subtruncate and slightly oblique; dorsal margin to all intents and purposes straight, but probably very slightly curved; front or ventral margin freely curved, more shapely so towards the anterior end, usually with a double edge, denoting the imperfect apposition of the two valves of the carapace; sculpture consisting of a transverse wrinkling, the test being probably papyraceous.

III.—Notes on the Geology, and Mining in the Trunkey and Tuena Districts: by G. A. STONIER, F.G.S., Geological Surveyor.

I.— General Physical Features.

THE observations refer only to such portions of the districts which the Author was enabled to inspect while dealing with specific instructions.

The district of Trunkey is within the Eastern Division of the Colony, but on the western fall of the Main Dividing Range. The township itself is 2,700 ft. above sea-level, and is generally approached from Newbridge, a station on the Western Railway Line. The country between these two settlements is very much of the same character, being, as a rule, undulating, without any steeply-inclined hills; but from Trunkey, in a southerly direction towards Tuena, the change is very marked, the creeks becoming confined between precipitous sides, and the hills rising in a short horizontal distance to a height of five hundred and six hundred feet above the water-courses.

The main drainage channel of the two districts is the Abercrombie River, which, although sinuous on a small scale, has a fairly direct westerly bearing. It is a rapid stream, and having a watershed of eleven hundred square miles, a small fall of rain will cause a flood, and on this account the working of the alluvial deposits below the present water-level has been attended with difficulties. Below the Rocky Bridge Creek the Abercrombie joins the Lachlan, the chief tributary of the Murrumbidgee River.

The Abercrombie receives various tributaries, such as the Copperhannia Creek, Grove Creek, Tuena Creek, &c., all of which are rapid streams with rough rocky beds and steeply-inclined sides.

Most of the land is utilised for grazing purposes only, the parts suitable for cultivation being of small area, and they have been neglected on account of the generally rough and mountainous character of the surrounding country. On some of the flats a little tobacco is grown by Chinese.

The timber consists principally of white and yellow box, apple-tree, stringybark, peppermint, &c.

II.—*Geological Features, with special reference to Mining.*

The formations developed may be classified as follows:—

1. Recent Alluvium 2. Pleistocene 3. Basalt 4. Eocene	Cainozoic.
5. Granite. 6. Diorite.	
7. Slates, sandstones, &c., with limestone, gneissoid rocks.	Upper Silurian.

1. RECENT ALLUVIUM.

These deposits are due to the action of the streams of the present day, and are being added to hourly. They consist of sands, clays, &c., with the more or less rounded blocks generally found in watercourses. As the latter are chiefly confined, the alluvials are found in bends of the rivers and creeks on one side or the other, and only at the heads of the streams do they assume the form developed by sluggish streams flowing through flat country. For this reason there are no extensive flats, and the various deposits which do occur are isolated. They are all more or less auriferous, and a large quantity of gold has been won, not only from the river, but also from the Copperhannia Creek, with its tributaries, Tuena Creek, &c.

The Copperhannia Creek has a large watershed, and above its junction with the Abercrombie is known by that name only as far as the Mountain Run Creek, when it passes under the name of Trunkey Creek till the Crooked-tree Creek joins it, and from there to its source it is called Mulgunnia Creek.

Each of the creeks has proved rich, and has been worked in the same manner as most of our alluvial leads, viz.:—First, by Europeans, who have mined the deposits with as much economy of time as possible, and of labour in particular; secondly, by Chinese, who are satisfied with a very much smaller return for their exertions; and in some cases, thirdly, by sluicing-parties. But that the three operations have not extracted the whole of the gold is evinced by the fact that at the present time various parties are making a living on ground previously abandoned as exhausted. It is, however, often difficult to bring a head of water, sufficient for sluicing purposes, on to a particular block of ground, and as the value of a claim depends

upon the ease with which it can be managed, speculators will not start operations without a definite expectation of success. A good deal of money has been expended in cutting races, making dams, &c., and doubtless advantage will be taken of these in the future for working some of the old points.

The Abercrombie itself has been rich, and gold won from it continuously for years. In many places the slates strike directly across the flow of the water, and have acted as natural ripples behind which the gold has accumulated. Most of the deposits worked have been of limited extent, and those still untouched present difficulties which are not readily overcome. In various places in the bed of the river there have been proved to be old waterholes which have become filled with auriferous drift. The mining of these is more difficult than the ordinary alluvial deposit, as the river must be temporarily diverted, and it is only during summer-time that work of the kind can be attempted. Then the old waterhole itself will be "wet," and means may have to be adopted either to pump out the water, or drain it by cutting through the bars of slate which cross the river and form the lower edge of the waterhole. There are doubtless several deposits of this kind which will well repay skilled attention.

The Copperhannia Creek has been worked and abandoned. The few Chinese settled along its banks divide their attention between tobacco-growing and "fossicking."

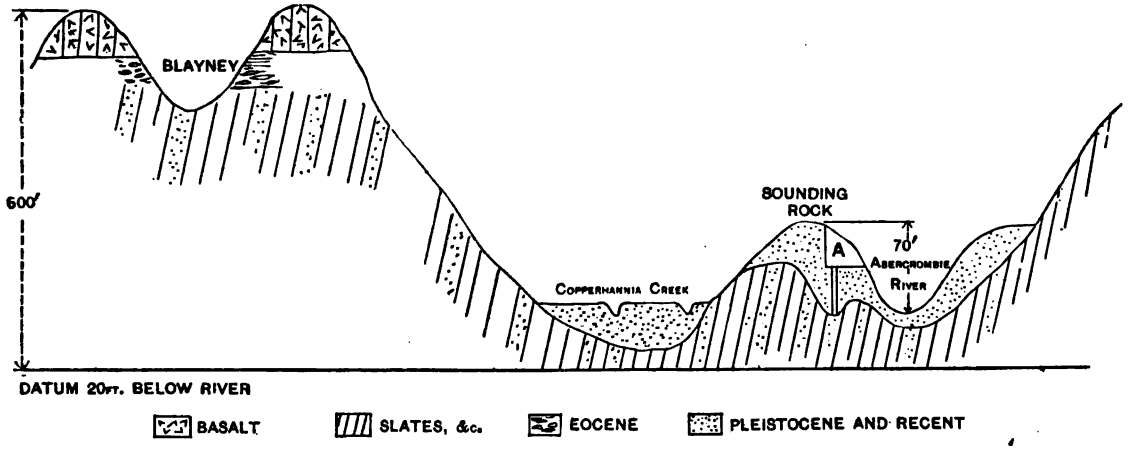
The Mountain Run and Crooked-tree Creeks are of special interest as examples of two distinct sources from which shallow placer deposits derive their gold. The former has a patch of Pleistocene drift, locally known as "the reef," running north and south, and the various gullies which break from it and bear easterly have been particularly rich, and this is not to be wondered at, as they are, in reality, the concentrates of the larger deposits. The latter (Crooked-tree Creek) runs past the township of Trunkey, and several nuggets, as well as fine gold, are reported to have been found at the southern end of the township. The creek cuts across an auriferous belt of country at a slight angle, and the gold has been derived from the wearing away of the veins occurring in the belt, particularly those on the eastern slope, the denuded material being subsequently transported and concentrated in the watercourse below. On the western slope some surfacing has been done, the presence of gold evidently being due to the disintegration of the rocks *in situ*. Surprise has been expressed that no payable vein has been discovered in the immediate vicinity of the surfacing, but it must be remembered that the gold results from the concentration of perhaps hundreds of feet of veinstone, and instances are not wanting in the Colony where the soil capping a reef will give a good prospect for every dish tried, while the reef itself contains only traces of the noble metal.

Tuena Creek has yielded a large amount of gold, and has been payable for a long distance. Few reefs have been discovered along its course. The Costigan Lode, unlike the Great Comstock Silver Lode, does not carry gold, so that it has not assisted in the enriching of the alluvial deposits.

2. PLEISTOCENE.

The deposits referred to under this heading occur, as a rule, at a higher level beyond the reach of existing floods, but it is difficult, and often impossible, to distinguish them from the preceding, for their mode of occurrence points to the fact that there was actually no break in the geological history, but that they were formed during one long and continuous period. As, however, there has been in some cases a considerable lapse of time between the formation of the two, it seems better to divide them.

At the junction of the Copperhannia Creek with the Abercrombie River, a claim known as the "Sounding Rock" has been continuously worked by Mr. Knowles since 1873. The river bears west, and near the junction, the Copperhannia Creek, which has previously had a southerly direction, turns south-westerly, leaving a thin tongue of land composed chiefly of alluvial, and on the eastern end of this the claim is situated. The following section shows its relation to the river and also to Blaney's Claim, which will be referred to later on.



As the river is seventy feet below the top of the deposit, and the wash would only pay if sluiced, it became necessary to make a dam on the Copperhannia Creek sufficiently far from its junction with the River to secure an adequate fall. A race was then constructed, having a length of about three miles. By this means water was brought on to the top of the deposit, and is now available for ground-sluicing any portion of it. At A the drift is exposed in a bank twenty-five

feet high, and, with the exception of the top six feet, it is said to carry gold all through. A little nearer the river a shaft has been sunk twenty feet before reaching bed-rock, the bottom being about on a level with the flow of the water. At the present time operations are being carried on at the northern portion. The wash is in parts bouldery, some of the boulders being several feet in diameter. They consist of quartz, jasper, slate, altered slate, &c., all well waterworn. The gold is mostly fine, with coarse specks up to seven pennyweights, and has a Mint value of £4 3s. 10d. With the gold is associated quartz, topaz, garnet, and zircon; diamonds also are reported to have been found.

This deposit, as already stated, has been proved to run to the level of the present river-flow, but deposits of the same age occur in the district above the level of the present watercourses; as, for instance, on the Mountain Run Creek, where D. M'Vickars has a claim from which he has won a good deal of gold by sluicing. Unlike the deposits in the bed of the river, the work can only be attempted during the rainy reason. The difference between the recent and older alluvium is clearer than at the Sounding Rock, and it is evident from the altitude at which the latter is found, above the former that considerable time has elapsed and the rainfall has much lessened since the close of the older period. The bed-rock is limestone, which has yielded readily to denuding agencies, and formed miniature gorges; therefore, the deposit is patchy, the rich parts isolated, and the formation itself does not appear to belong to any distinct lead. It forms part, however, of an old wide watercourse, resembling the rivers of the present day, which abound in water-holes and pot-holes. The stripping is on an average about twenty feet in width, increasing up to sixty feet, with wash in places four feet thick. The pebbles are well rounded, and consist chiefly of quartz up to ten inches in diameter. The gold is generally coated with iron oxide.

At Cook's Claim, on the Tuena Creek, between Tuena and the Abercrombie River, the necessity for dividing the alluvium into two ages is apparent, as the one occurs sixty feet above the other. The banks of the creek rise abruptly, and the occurrence of a deposit on either slope would not be expected. The wash is eight feet in thickness, and is bouldery in character, some of the blocks measuring four feet by two feet. They consist of quartz, quartzite, altered slate, and diorite (?), all well waterworn. The amount of attrition which the boulders have undergone is remarkable, and would seem to show that the force of the current which brought them into position was strong, rather than that they themselves have travelled any great distance. The drift has been worked for a width of forty feet, and a length of a chain and a half. It is blocked out in the ordinary fashion, and carted down to the creek to be washed. It is said to yield one pennyweight to the load.

Tuena Creek has evidently been of much more importance as a drainage channel in past times than at the present day, and it is surprising that no old channel of

Pliocene age has been found near its present course, or along the Cook's Vale Creek. If one was formed, all sign of it has long since disappeared. There is one small patch of basalt, but it is quite isolated and does not appear to overlie drift.

3. BASALT.

Basalt occurs variously as patches and outliers. Most of the specimens which have come under notice consist of a compact bluish-black variety, with a few small crystals of olivine porphyritically scattered through the mass, and in places a slightly cellular structure with the development of zeolites. To the west of Mulgunnia Station there is a patch running north and south for about three miles, with a width of about a quarter of a mile. About Thompson's Creek, between Tuena and Trunkey, a large patch occurs, but south of Tuena there is very little. Close to the township of Tuena is an outlier, which occupies a small area, and overlies an auriferous drift. The drift itself does not appear to contain payable gold, but it has been partly denuded into a gully close by, and there sufficiently concentrated to pay for working. To the south of Cook's Vale Station is another small outlier. The flows appear to be all of the same age, without any development of the older basalts, which can be well studied about Glen Innes and Inverell, and have been described by the late Mr. C. S. Wilkinson, F.G.S., &c., in various Reports. It is evident that a large area has been covered at one time by basalt, but so intense has been the denuding action since the flow of lava that in places outliers only are now left, where, at one time, there have been thick and large sheets.

4. EOCENE.

These beds are all overlaid by basalt, and consist of sands, clays, gravels, all more or less auriferous, and now, like the basalt, lying frequently in isolated patches, some six hundred and seven hundred feet above the level of the chief watercourses, such as the Abercrombie, the Grove, &c. The deposits define the position of drainage channels, which are the oldest of any in the district, and by comparing their altitude with that of the present channels, some idea can be gleaned of the enormous denudation to which this part of the Colony has been subjected, and the lapse of time between their formation and the deposition those of Pleistocene age. Fossil wood is of common occurrence, and from a shaft sunk by Mr. Nicholls, one and a half mile south-east of Trunkey, close to the Tuena Road, a stratum was passed through which contained an abundance of fossil leaves. A few were handed to Mr. W. J. Lee, the Mining Registrar at Trunkey, who has kindly presented them to the Mining and Geological Museum. The specimens are fragmentary but the following species have been provisionally determined by Mr. R. Etheridge, junr., Palæontologist to the Geological Survey, New South Wales:—

Apocynophyllum Etheridgei, *Ett.*
Ficus Burkei, *Ett.*
Trachyphyllum obtusum, *Ett.*

with the remark, "the first one has been previously found at Dalton, and the two last-named at the Old Rose Valley Lead, which is a tributary of the Vegetable Creek Lead proper."* The fossils are Australian types, and have been found in beds previously recognised as Eocene. The following section has been supplied by Mr. Nicholls:—Ten feet decomposed basalt; five feet fine ferruginous sand; one foot pipeclay, with leaves; eight to ten feet bouldery wash.

The deposits have been worked for gold in three places, but only to a small extent, and they are worthy of much more attention than has yet been given them. In most cases the difficulty has been to secure water in sufficient quantity for washing purposes, as cartage to the creek is generally out of the question. At the southern end of the basalt range, which is to the east of Mulgunnia Station, a rich patch has been worked. The lead was not well defined, and the richest gold occurred on top of a bar five feet above the channel. The lead is supposed to run north, and a couple of shafts have been sunk, with a view of fixing its position; but for want of funds the work had to be abandoned. Schultz and Party are now receiving aid from the Prospecting Vote to drive a tunnel to drain the ground, and should they be successful in striking payable wash, a large extent of country will be opened up.

On the range between Mulgunnia and Camp Creeks a crop of wash runs west, but the prospects obtained have not been encouraging. Parallel to the Copperhannia Creek, and on its eastern side, crops of wash occur in isolated patches. They are auriferous; but, as the hills are steep, the working is attended with difficulty, for if water be obtained by races run round the hillside the catchment area is small and the supply also intermittent; and if cartage be attempted to the creek, four hundred and five hundred feet below, the expense is more than the yield of gold will warrant. At the present time Blaney's is the only claim working. The wash is seven feet thick, and is said to go three pennyweights to the load. The lead is of a bouldery character, some blocks being two and a half feet in diameter, all well waterworn, and cemented by ferruginous clay. The boulders consist chiefly of quartz resembling in appearance birds' eggs, quartzite, altered slate, and decomposed diorite. Three diamonds are reported to have been obtained, two of which were sent to Sydney, and the third one broken on a blacksmith's anvil to prove whether its resistance to a crushing stress was equal to its hardness as a gem.

It is evident that there are portions of the lead which will pay to work, and the difficulty of water supply may, perhaps, in some cases be met by a scheme for pumping from the creeks. The wash itself should be quite rich enough but the question of water has baffled hitherto all attempts to deal with it on a large scale.

* Ann. Report Dept. Mines N. S. Wales for 1891 [1892], p. 268.

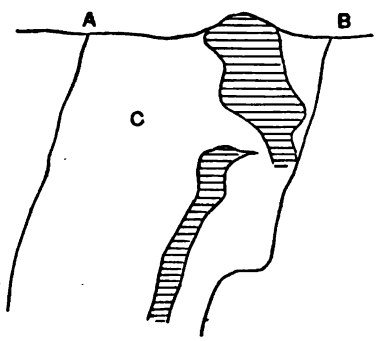
5. GRANITE.

The granite occurs chiefly as dyke-masses, which are doubtless offshoots from a granite boss, and may have some connection with the Bathurst granite on the north, and the Binda granite on the south. It generally makes a good outcrop, but appears to run rather irregularly. As a rule, the dykes have followed the bedding-planes as the most easy passage, and in places have indurated and silicified the rocks at the actual junction, although the alteration does not extend far from the line of union. The rock itself is variable, and ranges in a short distance from a coarse aplitic granite to a felspar porphyry. The masses appear to be of the same age, and there does not seem to have been any later intrusion. The system of upheaval is probably north and south.

6. DIORITE.—A large dyke occurs at the Pine Ridge, and is referred to in the "Annual Report of the Department of Mines for the Year 1877."

7. UPPER SILURIAN.

(*a*) Trunkey District.—These beds occupy a large area, and are of importance about Trunkey, because of the reefs which occur in them. They are certainly older than the Devonian Series which has been mapped by the late Mr. C. S. Wilkinson at Rydal, and are classified as Upper Silurian on stratigraphical grounds only, as no fossils have yet been described, although large deposits of encrinital and coralline limestone are included in the series. In these limestones occur the beautiful Abercrombie Caves, described by Mr. Wilkinson.* The formations comprise sandstones and slates, the latter of a bluish-black colour, with cubes of pyrites sprinkled throughout the rock-mass. At Trunkey the bedding and cleavage appear to be coincident, but nearer the Abercrombie River, along the Tuena Road, the two are clearly seen to diverge. The beds generally have undergone a certain amount of silicification, and by the intrusion of the granite the contact rocks have been converted in places into quartzite, while a study of the outcrop of the reefs would seem to show that the fissuring of the rocks has not stopped at a clean fracture, but that the strata near each crack have been subject to the same movement on a small scale. This can be seen at the Old Pioneer Mine, from which the following section has been taken :—

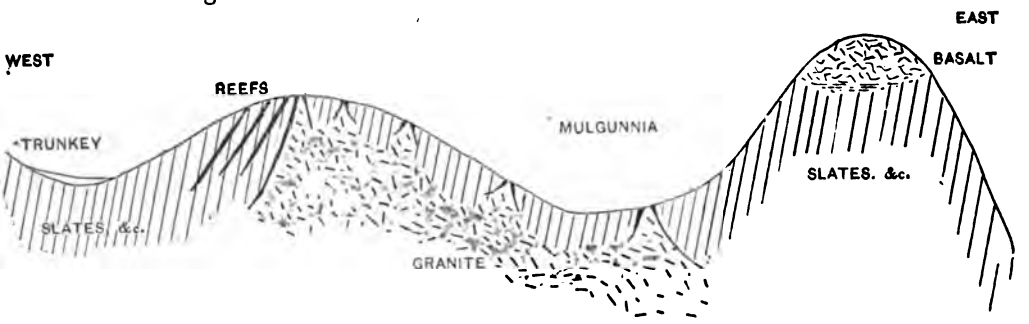


At A and B are defined walls, and at C the beds are separated by white clay, which at first sight might be thought to be interbedded; but evidently it is due to the movement of one layer upon the other with the production of a "dig," which now separates each individual stratum.

The reefs are of interest, not only on account of the quantity of gold which has been, and may again in the future be won, from them, but because of the special mode of their occurrence.

* Annual Report Dept. Mines N.S. Wales, for 1877 [1878], p. 206.

In going from Trunkey to Mulgunnia slates, &c., with reefs are passed over, and then on the crown of the hill there is a change in the formation, as shown on the following sketch :—



At first sight it appears to be wholly an intrusive boss, but closer investigation shows that it consists of sediments intruded by granite.

The occurrence of the metalliferous veins in Cornwall has been carefully studied, and it has been demonstrated that there are two distinct systems of fissures which are due to :—

(1) The fracturing of the sediments by an upheaval of granite.

(2) The fracturing of the sediments and granite due to the depression of the latter.

The conditions under which the Trunkey reefs have formed seem to me to correspond with the first. Denudation has not gone far enough to show the apex of the granite boss, but its existence is indicated by the numerous masses which come to the surface. The second class of veins have not formed in a well-marked series, but they may be represented by the reef dipping east, which has been worked at the New Bathurst Company's Property. As a rule, the veins run nearly north and south, and underlie west; and although coinciding with the strike of the slates, they underlay at a greater angle. They have been worked to seventy feet, the water-level, for a distance of about a mile, while the line of reef has been found to contain gold for four miles.

The deepest shaft on the field is that of the New Bathurst Company, and stone has been worked at the six hundred and fifteen feet level, where the vein was five inches thick.

At No. 7, Mr. Fulton, the Manager, has sunk a vertical shaft three hundred and twenty-two feet deep, and is now driving east to cut the veins which have been worked at the surface.

It will be seen from the late Mr. C. S. Wilkinson's Report*, that within a width of a quarter of a mile eight distinct veins have been opened, and these vary from two inches to three feet, with an average width of six inches to eight inches. Their outcrop is characterised by the occurrence of large blows of white opaque quartz. The blow itself does not carry payable gold, which is confined to stone half an inch thick either one side or the other, but generally on the western side. The auriferous veinstone forms part of the larger mass, and has often been left on account of the difficulty of detaching it from the barren quartz. Having proved, by carefully trying the soil all around the blow, which side the gold is on, the vein is opened out, and the auriferous stone found to gradually thicken until it occupies the whole width of the fissure, and dips either north or south, but generally north.

An examination of the outcrop shows that on the whole the shoots of gold are regular and of a fair length, in some cases as much as a chain. The amount of dip is more variable than the direction.

Few cross-veins have been found, although one was worked which was in places four feet wide and very rich. The vein is exceptional, and the main line does not appear to have been subject to much faulting, the loss of "stone" being due to the disappearance of the shoot of gold rather than to a displacement of the reef. Considered as a whole the veins are narrow, but with the facilities which there are for working they should afford employment for a number of miners. In many cases the shoots have a fair length, and favour the expectation that, although the difficulties are increased now that the water-level has been reached, the shoots should be profitably worked.

In going over the ground it is hard to resist the impression that the general meridional strike of the sediments is due rather to terrestrial movements than a local cause. The intrusion would seem to have been subsequent to the arrangement of the beds in their present position, and the granite, from which dykes have followed the bedding planes, has fractured the strata, producing cavities into which quartz, &c., in solution, and forming the veinstone, has afterwards infiltrated. The dykes themselves being thin have not contracted much, and there have not been the conditions for the formation of a well-marked series of veins dipping in towards the granite.

The Abercrombie Caves are about nine miles south of Trunkey, and near them is situated the Mount Gray Mine, where there is a large outcrop of quartzite, &c., including slate bands, covering a width of one hundred feet, and which can be traced for several chains in a northerly direction, shutting off close to limestone. On this outcrop a shaft has been sunk forty-six feet, and from the bottom of the shaft there is said to be a drive bearing east thirty-three feet, at

* Ann. Report Dept. Mines N. S. Wales for 1877 [1878], p. 206.

which point a footwall was struck. I was unable to see either shaft or drive as they had both collapsed. The stone varies in character from a slightly ferruginous quartzite to a siliceous ironstone, passing into sugary-quartz, with cubical cavities up to half-inch in diameter, resulting from the decomposition of iron pyrites. From various specimens rich assays have been obtained, and Mr. Grosvenor, the Manager, informed me that a crushing of thirty-six tons taken from the thirty-three feet drive gave a yield of three grains short of seven pennyweights per ton. A tunnel, now three hundred feet in length, is being driven north towards the forty-feet shaft, which is distant three hundred and fourteen feet, and in order to meet it the shaft will be sunk a further depth of thirty feet. The tunnel started in slate, which soon gave place to a highly ferruginous clayey-lodestuff with, in places, boulders of quartzite and angular fragments of slate; then slate was again met with, and at the time of my visit there were signs of more brecciated lodestuff. No defined wall can be seen, although the clay has all the appearance of lodestuff, and with the small amount of work done it is impossible at present to determine whether there is a large fissure or whether a limestone bed has been fissured and partly replaced by silica, &c., from heated waters percolating from below. Near the outcrop there is no sign of limestone, but some specimens of quartzite are calcareous.

To the west of the main deposit is a large mass of limestone, and through it in lenticular patches, are masses of siliceous material similar to the outcrop quartzite already referred to.

At Newbridge brown iron ore occurs in irregular patches in a large lode measuring at least twenty-four feet in width, which is due to an upheaval of granite, and it is possible that the Mount Gray deposit has resulted from a similar intrusion.

Other reefs, such as Wilson's Reef at Pine Ridge, Trunkey Consols, &c., have been worked in the district, though none are at present doing anything.

(*b*) *Tuena District.*—About Tuena several gold reefs, such as the Lucky Hit, are at work, and although the alluvial has yielded a large quantity of gold the lodes have produced principally silver and copper. Peelwood was opened many years ago, and smelting has been carried on at Mount Costigan and Cordillera, but at the present time all are shut down.

The rocks about Tuena differ widely from those at Trunkey, and may possibly be older, but they have not been separated on account of the absence of any evidence to demonstrate the difference in age. Limestone, which has not yet

yielded determinative fossils, occurs within a short distance of Tuena, and there does not appear to be a break in the sequence of the beds, so that it may be that while at Trunkey there is contact metamorphism on a small scale, the alteration in the rocks at Tuena has been greater and more extended.

At Mount Costigan there is a marked belt of altered rocks, measuring one hundred yards wide, and occurring on the eastern or footwall side of the lode, with a series of slates, sandstone, &c., not so highly altered. The belt resembles in lithological occurrence sediments on edge, and the examination of a hand specimen shows the presence of crystals of felspar and blebs of quartz in a siliceous base, the whole having been subject to stresses which have induced cleavage. The rock is probably an altered sediment, and not a plutonic rock, which has assumed a schistose character owing to mechanical movement, and my examination failed to trace any evidence of portions having become so soft as to be squeezed into cavities, and simulate true granite. South of Costigan the character approximates more closely to granite.

The rocks to the west of the Costigan Lode are slates much contorted and more or less indurated and silicified, having a lustrous silvery-sheen due to the cleavage planes. The occurrence at Peelwood of an example of contortion on a small scale has been described by Professor Liversidge.* The Professor concluded, after various inquiries, that the contortion was local, but an examination of the district would have shown that the plication has extended for a length of at least nine miles. There has not been an opportunity of determining the width of the belt, but a projected visit to the south of Tuena may throw some light on this point. The rock varies from a talcose slate to porcellanite, parts of the base being very siliceous, approaching a finely granular quartzite, and becoming quartzose. Examples of true contortion are more common than has been supposed, and occur fairly frequently in various parts of New England.

Mines have been opened out, and smelting operations conducted at Mount Costigan, Cordillera, and Peelwood, but the ore has not been found in any instance outside the original discovery. Whether or not there has been any actual fissuring can only be determined by a careful examination of the deposits, which cannot at the present be attempted. The small portion of the Cordillera Mine which can be seen does not give sufficient information to settle the question, and the evidence which is available points to an irregularity in the deposits, although the absence of defined walls can be fully accounted for by the dissolution of the walls and saturation of the country itself on either side. It is clear, however, that there has been movement, whether of the character to form true fissure veins or not, and coupled with it metallic solutions have circulated through the cavities formed, and it is a

* Minerals of New South Wales, 1888, p. 232.

surprise that more ore-bodies have not been found. That there has been much infiltration of waters with quartz in solution is evinced by the number and size of the quartz-blows, which form a feature in the district. The Peelwood Mine has been worked to six hundred feet, and speaks well for continuity in depth, at any rate, of some of the ore-bodies. It is evident that it would be unwise to spend much money without some favourable sign of the existence of mineral, and it is quite as certain that the driving of a tunnel at right angles to the course of the lode, and not, as in one instance, parallel to it, will not prove the country, because it may happen to cut the fissure or ore-body at the particular point where the walls meet. When a lode is discovered, the rational method of proving it is by following the mineral wherever it may go, and even should it cut out to follow the walls or drive along the lode, and prove whether these may not open and admit of the mineral making. Although at the present time the mines are closed, doubtless there will be employment for many men when the ores are understood better, and the mines worked for the mineral and not for the share market.

Various deposits of ironstone and limestone are found in the district.

IV.—Notes on the Intrusive Serpentine at Gundagai: by P. T. Hammond, Field Assistant.

Whilst on a visit to Brummy's Hill Alluvial Mine, at Gundagai, a few months ago, my attention was attracted by some highly metamorphosed talcose and micaceous slates in the locality, which appeared to pass by imperceptible gradations into the serpentine which outcrops strongly on the west side of the alluvial claim, and from what I then saw the idea was conceived that the serpentine of that locality might have resulted from the metamorphism of the slates. Following out this idea, the junction with the slates on the hill was examined, as closely as the time at my disposal would allow, on the side on which the claim is situated, and found that there was a rather sudden and decided change at this point from the highly inclined slates to the serpentine, which is fairly strong presumptive evidence, taken in conjunction with the crumpling of the strata to be observed at this point, and the presence of ill-defined felspar crystals in the serpentine, that the latter has here resulted from the decomposition *in situ* of a basic eruptive rock which has been intruded along the bedding-planes of the slates.

This eruptive mass can be traced in a northerly direction across the Murrumbidgee River, and through a portion of the town of Gundagai.

Travelling thence along the road to Eurongilly, after passing over an alluvial flat, and following the course of the river for some distance in a westerly direction, a very good section may be seen which has been exposed by the road-cutting, and consists principally of very talcose green slates, passing at times almost into a soapstone, and containing small calcite veins, the beds having a more serpentinous appearance as they approach the junction with the eruptive rock; the alteration having evidently been induced by contact with it. I would, therefore, suggest that this locality is worthy of a closer inspection, which would go far towards settling definitely the question as to whether our serpentines do or do not in any case result from the alteration of sedimentary beds.

I have also observed a similar serpentinous character in the slates at Muttama, and on a hill to the west of the town of Parkes, but have not in either case been able to trace a passage into actual serpentine.

V.—Notes made at the Kybean Caves, Parish of Throsby, County of Beresford, in October, 1890, by W. S. Leigh and R. Etheridge, Junr.: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plate V.]

I.—Locality.

THE Kybean Caves are situated, as reported by Mr. W. S. Leigh*, Inspector of Caves, about twenty miles south-east of Cooma, in the Parish of Throsby, County of Beresford, between two small gullies, branches of a tributary of the Kydra Creek, locally known as the Great Limestone Creek. The Kydra Creek is itself an affluent of the Kybean River, which joins the Umaralla River some little distance above Danjelong Station.

As already noticed by Mr. Leigh, the caves are situated in a limestone spur, running practically north and south, and at an elevation of about fifty feet above the flat of Great Limestone Creek, the rise of the limestone spur itself being a very gradual one. The Kybean is said by the late Rev. W. B. Clarke to be between 3,400 feet and 3,700 feet above sea-level.†

* Ann. Report Dept. Mines N.S. Wales for 1890 [1891], p. 311.
† S. Goldfields, 1860, p. 142.

II.—The Caves.

The caves, or rather crevice-chambers, opened out by Mr. S. J. Elphick, the temporary keeper, are five in number. Immediately at the side of the branch creek —in fact, almost in it, and about fifteen chains from its junction with the Great Limestone Creek—is an opening termed the "Bullock Hole" (Pl. V. No. 1.), which at the time of our visit had not been explored, beyond ascertaining that it communicated with the first small chamber of a contiguous opening, called the "Buttress Crevice" (Pl. V. No. 2,). This opening is on the side of the rise, a little above the Bullock Hole, and extends downwards, as a small passage, for forty-nine feet, at an angle of forty-five degrees, in a westerly direction. At twenty feet from the surface is the small off-shoot previously referred to as communicating with the Bullock Hole. At thirty feet from the surface is a small chamber to the left, fifteen feet square, containing a few small stalactites and a buttress formation. The whole is little more than a watercourse crevice filled with blocks of limestone, yellow unctuous clay and *débris*, and marsupial bones, chiefly those of the Kangaroo, Wallaby, and Wombat. The passages are about nine feet square, but would probably be larger if entirely cleared of blocks, &c.

At about thirty paces in a north-west direction from the mouth of the Buttress Crevice, and still going up the rise, is the entrance to the "Danjelong Cave." This is a vertical descent of seventeen feet. From the bottom leads off an irregular passage in a westerly direction, curving round to the north, when it divides into three subsidiary passages. The right-hand opens in height, leading northwards for perhaps twenty to thirty feet, and contains bottle-shaped stalagmites. The left-hand branch is very narrow, passing upwards for a few yards, and contains a little bone-breccia *in situ*. The central passage, equally narrow, is blocked by a very large mass of limestone, probably at some former period detached from the roof. The space between this block and the roof is not more than fifteen inches,* through which the visitor has to crawl in a prone position for about ten feet, landing in a small chamber some twenty by ten feet in area, which again communicates by a very small passage with a terminal chamber. Here are displayed the best stalactites of the whole group of passages and crevices, and although not of large size they are well formed and intact, probably owing to the difficulty of access over the block of limestone previously referred to, for these caves had, to some extent, been visited and vandalised before they came under the notice of the Department. Mr. Leigh thus refers to the contents of this cave:—"A very fair collection of stalactites and stalagmites of various forms, some of which are pure white, and almost transparent, whilst others are of a light-brown tint."

*Leigh, Ann. Report Dept. Mines N. S. Wales for 1890 [1891], p. 311.

The portion now forming the right-hand branch was probably once a small chamber, but is filled below its present floor with successive layers of bone-earth and stalagmite. At his first visit, Mr. Leigh was successful in discovering a layer of bone-breccia in this part of the cave, and remarks in his Report:—"I examined the cave very minutely during this inspection, and was successful in finding, in its lower depths, a layer of bone-breccia, about two feet six inches thick." Between the occasion of this Report and that of our visit, Mr. Elphick had sunk into this deposit to a depth of eight feet, without reaching the limestone below, and had passed through several layers of bone-earth.

About eighteen paces further on towards the crown of the rise is the entrance to the "Elphick Cave," a vertical hole fifteen feet deep. Two branches lead off, one a little east of north for about twenty-two feet, descending at an angle of twenty degrees, and just large enough to crawl through. It is partially filled with red earth. The second passage has a nearly western direction, ending in a small chamber about fifteen feet square, although lofty. A communication exists with the exterior by a small air-hole, high up in the roof of the chamber, opening to the day at some point further up the spur.

There are a few stalactites, and some bones were found by Mr. Elphick loose in the red earth of the floor.

Leaving this cluster of openings, and proceeding a little further up the creek, on the side of the limestone rise, is another vertical hole, leading to the "Kydra Cave," sixteen feet deep. A very irregular passage, both in width and height, is then traversed for sixty feet. It is filled to a great extent with large blocks of stone and earth; but at the entrance there are successive stalagmitic floors containing sparsely-scattered bones. The stalactites are insignificant, but the sides of the passage are covered with a buttress formation.

The size of the caves and the stalactites were not considered of sufficient importance by the Inspector to warrant him in recommending any further outlay in connection with these openings, nor is there that extent of limestone which would lead us to anticipate any very large and important chambers. In fact, the whole of the openings appear to have been drainage channels into which surface material has been repeatedly washed, the passages here and there opening out into small chambers, in some of which the transported material became settled down and roughly interstratified with stalagmitic floors, each one of these denoting a quiescent period, when no new matter was added.

III.—Red-Earth Deposit.

From a strictly geological point of view, the deposit of red earth, sometimes ossiferous, and the stalagmitic floors are the most interesting points about the Kybean Caves, although of so limited an extent.

In general appearance the red earth more or less resembles that of the Wellington Caves, but is of a less decided colour, and, in comparison, but sparingly ossiferous. Its position in the various passages has already been described, but the principal deposit is in the central division of the Danjelong Cave, where it was sunk into to a depth of eight feet without reaching the limestone bottom of the passage. Most of the rock crevices and two or three smaller passages are similarly filled.

In the collection of bones made there is an entire absence of the extinct genera of our Post-Tertiary Marsupials, such as *Nototherium*, *Diprotodon*, *Thylacoleo*, or *Thylacinus*. The remains appear to be those of Kangaroo, chiefly limb bones, with traces of the Wombat. From this it may be justifiably concluded that the accumulations in the Kybean Caves belong to the latter period of Cave-deposits, and not to the more ancient, such as those of the Wellington Caves.

IV.—The Kybean Limestone.

The limestone does not show any determinate strike or dip, but appears above the surface in irregular blocks and patches of no great dimensions. It weathers externally a dark blue-grey in colour, but on fracture is usually white, with yellow and yellowish-red blotches. The texture is homogeneous and highly crystalline, and, so far as I saw, quite unfossiliferous. This is unusual, as most of our cave-limestones are crammed with organic remains. The limestone forms a more or less elongately triangular patch, tailing off in a north-easterly direction in a long, ill-defined, tongue-shaped line. On the rise to the east the flaggy shales strike almost due north, with an easterly dip at fifty degrees, but in the main creek, to the south-west of the limestone, the strike is N. 10° W., the dip still easterly, varying from forty-five degrees to vertical. The surface is quite devoid of timber, the re-appearance of the latter along the north boundary forming a well-marked line of demarcation between the deposit and the enclosing shales and grits.

The only evidence we possess as to the age of the Kybean Limestone is furnished by a few fossils obtained by the late Rev. W. B. Clarke, F.R.S., from the shales and mudstones of Danjelong. These were determined by the late Professor L. G. De Koninck, and are as follows :—*

Ptychophyllum patellatum, *Schl.*
Strophomena pecten, *Linn.*
Pterinea ampliata, *Phill.*

So far as an opinion can be formed from so limited an amount of material, the beds in question would appear to be Wenlock.

* Rech. Foss. Pal. Nouv.-Galles du Sud, Pt. 1, 1876, p. 12, *et seq.*

VI.—Notes on the Teeth known as *Sceparnodon Ramsayi*, Owen (*Phascolonus gigas*, Lydekker): by W. S. DUN, Assistant Palæontologist and Librarian.

[Plate VI.]

I.—Introduction.

A CONSIDERABLE amount of speculation has already been indulged in respecting these peculiar teeth, which were first described by Sir Richard Owen, from specimens sent to him in 1881, chiefly by Dr. E. P. Ramsay. These teeth were found in Post-Tertiary deposits at Lake Eyre, South Australia, Gelgoine Station, New South Wales, and King's Creek, Queensland. Since that date a considerable number have been found at Bingera, in deposits considered by Mr. W. Anderson* to be of Pleistocene age. Other specimens have been found in Queensland.

In this Paper it is the intention of the Writer to give a brief review of the conclusions arrived at by previous observers on the subject, and to describe some additional specimens of single teeth in the collection of the Mining and Geological Museum of the Department of Mines, Sydney.

II.—History.

In 1883, Sir Richard Owen† described and figured casts and specimens of teeth from Lake Eyre, Gelgoine Station, and King's Creek. He described these as rootless scalpriform teeth, and considered that they belonged to an animal almost appoaching *Diprotodon*, *Nototherium*, and *Phascolonus*, in point of bodily size, but widely separated from them by reason of the abnormal flattening of the incisors. The section of these teeth, from the proportion of the enamel, cement, and dentine, more nearly corresponds to those of the Wombat than of any other marsupial. He notes the bevelling of the inner surface, the curve of the cutting edge, the presence of a median ridge, and the fact that on the inner edge there is a depression, probably caused by the pressure of a contiguous tooth. Sir Richard Owen considered that these teeth represented the upper incisors of an extinct marsupial, more similar to the Phascolomyidæ than to any other family, but differing from them by the great breadth of the upper incisors.

The next to describe these teeth was Mr. R. Lydekker,‡ who, noticing in 1887 that whereas there were no specimens of *Sceparnodon* showing cheek-teeth, and that no upper incisors had been assigned to *Phascolonus gigas*, suggested

* Records Geol. Survey N. S. Wales, 1889, I, Pt. 2, pp. 116-125.
† Phil. Trans. R. Soc., 1884, 175, Pt. 1, p. 245.
‡ Cat. Foss. Mamm. Brit. Mus., Pt. V, pp. 157, 158.

that the incisors hitherto known as *Sceparnodon* might be in reality the upper incisors of *Phascolonus* (*Phascolomys*) *gigas*. He supported this suggestion by the following evidence*:—"1. The incisors of *Sceparnodon* agreed fairly well in relative size with the jaws and cheek-teeth of *Phascolomys* (*Phascolonus*) *gigas*; 2. the incisors of *Sceparnodon* were decidedly of a wombat-like type, differing mainly from those of existing Wombats by their large size and excessive flattening and expansion; 3. one of the incisors of *Sceparnodon* agreed so closely in the structure of the enamel, and the reddish stains upon the same, with an upper premolar of *Phascolomys gigas*, that I even suggested both teeth might have belonged to the same individual animal." After this Mr. Lydekker examined three imperfect incisors of *Sceparnodon*, and part of the right ramus of a mandible of *Phascolonus gigas*, from Bingera, which formed part of the Department of Mines exhibits at the Crystal Palace during the late Mining and Mineral Exhibition. From the examination of this portion of the lower jaw he gathered sufficient evidence to justify the alteration of *Phascolomys gigas* to *Phascolonus gigas*, and, as regards the great width of the anterior part of the symphysis, considered it "as being apparently adapted to fit with the wide upper incisors, described as *Sceparnodon*." From the further examination of the *Sceparnodon* teeth, and comparison with the lower molars of *Phascolonus*, with which, allowing for their excessive width, they were not out of proportion, Mr. Lydekker arrived at the conclusion "that we are now justified in definitely regarding the so-called genus *Sceparnodon* as based upon the upper incisors of the gigantic extinct Wombat known as *Phascolonus*," and that "from the great width of the upper incisors, as compared with the lower ones, it is pretty evident that the former must have worked somewhat obliquely against the latter."

Another very important Paper, however, has just been contributed by Mr. C. W. De Vis,† Curator of the Queensland Museum, in which he records the discovery of an incisor of *Sceparnodon* with part of the præmaxilla still attached. From the examination of this portion of the præmaxilla, Mr. De Vis considered that *Sceparnodon* could not have belonged to the Phascolomyidæ, because of the smoothness of its inner edge and the absence of any sign of sutural junction, both of which points are reversed in the family Phascolomyidæ. He likewise describes a smaller imperfectly-developed tooth with a greater extent of working surface, which he considers to be a lower incisor. In this paper Mr. De Vis lays especial stress upon the following points:—1, the absence of a median ridge in some specimens; 2, the relative extent of the working surfaces; 3, the presence in some teeth of a well-marked depression on the inner border.

The tooth described by Mr. De Vis as a lower incisor is characterised by the presence of a well-marked median ridge, a larger proportion of abraded surface, and the presence of a strongly-marked depression on the inner side, which he

* Proc. R. Soc., 1891, XLIX, pp. 60-64.
† Proc. Linn. Soc. N.S. Wales, 1891, VI. (2), Pt. 2, p. 258.

attributes to the chopping action of the upper incisors. From the consideration of this evidence it must be admitted that there are two separate forms of teeth, and that these are either to be considered as upper and lower incisors respectively of *Sceparnodon*, or else, for an alternative, we must imagine that there are two species of *Sceparnodon*, of which the upper incisors alone are known.

III.—Description of new Specimens.

The specimens about to be described were collected at Bingera, in 1888, by Mr. C. Cullen, Collector to the Geological Survey. The alluvial deposits they occur in are of Pleistocene age, and have been described by Mr. W. Anderson,* Geological Surveyor.

The specimens are about thirty in number, and consist principally of fragments, most of which, however, show the working edge of the teeth. They all present the characteristic colour of the Bingera fossil bones, being of a pale-fawn tint. The outer surface is convex, and covered with a coating of enamel, about a millimetre in thickness. This surface is roughly striated, whilst the inner concave surface has fine longitudinal lines running parallel to the sides, in some cases there being also a strongly-marked median ridge. I have been able to divide these teeth into two distinct classes, the one consisting of those with well-marked depressions on their inner edge, the other having merely a worn surface without any marked scars caused by abrasion. From the examination of these teeth, I cannot agree with Mr. De Vis that the median ridge is to be considered as a characteristic sign of any particular set of teeth, as it is by no means confined to those which show the action of chopping, but is most markedly present in several which merely exhibit a bevelled inner edge. Of these two kinds of teeth, those having the strongly-marked depression on their inner edge have invariably a larger expanse of working surface, which is continued downwards on the outer edge of the tooth in a tapering tongue. Of the first class of teeth, which, apart from the fact that some of them do not possess a median ridge, may be considered to agree with those considered by De Vis to be lower incisors, it may be mentioned that the working edges of some show a decided wearing away, the sharp edge being replaced in one case by one 1·4 mm. thick, several others showing this in a less marked degree, whereas one, Pl. VI, Fig. 6, shows that the corner of the inner edge has been broken away and subsequently worn smooth by the action against an opposed tooth. This form of wearing seems to favour the opinion that the tooth in question was an upper incisor, and opposed to a lower tooth which was much narrower in shape, more nearly approaching those of *Phascolonus gigas*.

* Records Geol. Survey N.S. Wales, 1889, I, Pt. 2, pp. 116-125.

Dividing the teeth into two groups—the one (A) possessing a strongly-marked abrasion, the other (B) showing merely a worn surface—we get the following results from a comparison of the measurements of, 1st, the depth at the middle of the working surface, and 2nd, the length of the cutting edge:—

Group A.—Five specimens—average depth of working surface	15·4	mm.
Maximum depth	19	mm.
Minimum do	10	mm.
Group B.—Eight specimens—average depth of working surface	16	mm.
Maximum depth	20	mm.
Minimum	12	mm.

Showing an excess in favour of the teeth in group B of about 6 mm.

Group A.—Five specimens—average length of cutting edge ...	39·8	mm.
Maximum do do do ...	42	
Minimum do do do ...	38	mm.
Group B.—Eleven specimens—average length of cutting edge	39·7	mm.
Maximum do do do ...	42	
Minimum do do do ...	35	mm.

Showing a slight excess in favour of Class A.

From this comparison we see that whereas the teeth of Group B have a greater depth of working surface they have a slightly shorter length of cutting edge. These differences of depth of working surface and length of cutting edge hardly seem sufficient to separate the teeth into upper and lower incisors respectively; and I think that it is most probable that those teeth showing the scars on their inner edge are, as Owen and Lydekker describe them, upper incisors, and that the scars show the limit of action of the lower incisors. So far as this class of teeth is concerned, there is no evidence beyond their abnormal width and fragile nature counter to the fact that they may represent the upper incisors of *Phascolonus gigas*, or of some extinct marsupial possessing a somewhat similar type of lower incisor. But if we take this as conclusive, the position of the second class of teeth has to be determined, and they seem to show no marked scarring similar to the teeth in Group B; and again we have the upper incisor described by Mr. De Vis, which shows no scar, and is still attached to a portion of the præmaxilla.

Owing to the fragmentary state of all teeth which have as yet been brought to light nothing can be stated with perfect certainty. Two most conflicting statements have been made, one Author stating that the lower jaw is occupied by Phascolomine incisors, while the other describes teeth of another type as holding that position. The evidence before us, while showing that there are two classes of teeth, does not prove either of the former opinions to be erroneous, though certain of the characteristics claimed by Mr. De Vis for the lower incisors have been proved to be by no means constant.

VII.—Notes on the Occurrence of Opal in New South Wales: by WILLIAM ANDERSON, Geological Surveyor.

OPAL has long been known to occur in many localities in this Colony, but until the discovery of the opal-field near Wilcannia, the individual specimens obtained had not been of sufficient size or brilliancy to initiate a commercial demand for the gems. Of late years the supply of Australian opal has been derived chiefly from Bulla Creek, Queensland, where it occurs in the form of kernels, filling the centres of ironstone nodules. They usually attain a considerable size, and a large percentage of them consist of precious opal.

In New South Wales precious or noble opal has been found in small quantities, along with the inferior qualities, at Rocky Bridge Creek, Abercrombie River, County of Georgiana, in an amygdaloidal basalt; at Trunkey; in clay ironstone in the Wellington District; at Louisa Creek; at Bland, near Forbes; at Coroo, with chalcedony, agate, &c.; and at Bloomfield, near Orange.

Common opal and opalised wood are of very frequent occurrence in all the Tertiary basaltic districts of the Colony, but they are of no commercial value, because, although they take a high polish, they want the brilliancy and play of colours which belong to the precious opal.

Opal generally occurs as a secondary product in igneous rocks, sandstones, limestones, and in some metalliferous veins. It is usually the result of the deposition from solution of opal-silica in cavities during its percolation through the rocks. It is, however, sometimes deposited from hot springs. The cavities which it occupies in rocks may be cracks or joints, or the hollows left by the decomposition of various minerals. The substance of the opal is often rendered impure by remnants of the decomposed constituents of the rock, as well as by the presence of hæmatite and other foreign materials. The most valuable variety, precious or noble opal, is of comparatively rare occurrence, its chief sources being Hungary and Central America. The other less valuable varieties are met with frequently in many other parts of the world.

The locality in which opal has recently been discovered in New South Wales is known as the White Cliffs, on Momba Holding, about sixty miles in a north-westerly direction from Wilcannia. The country in this neighbourhood forms part of the great western Cretaceo-Tertiary Plains, and is, consequently, flat, with here and there a few isolated hills rising from it. The plain-like country is formed of horizontal Cretaceo-Tertiary strata, while the hills and rising grounds consist of

various formations. To the west of Momba they consist of vertical Silurian slates and horizontally-bedded Devonian conglomerates and sandstones, both of which represent the denuded summits of the land surfaces which existed in this area during the deposition of the Cretaceo-Tertiary beds. Besides these, however, some of the rising grounds are formed of very siliceous, horizontally-bedded sandstones, which undoubtedly belong to the Upper Cretaceous, and are probably equivalents of the Desert Sandstone of Queensland. These latter are very easily mistaken for outliers of Devonian sandstone, the mode of occurrence and general configuration of the denuded outliers of the two formations being very similar; although the Devonian rocks are always ferruginous and dull, while the Desert Sandstones are usually a pure white, hard, glistening, siliceous sandstone, with almost a vitreous look.

The opal in its occurrence here is confined to the vitreous-looking Desert Sandstone, and the alluvial deposits which have been formed from its denudation. Its chief source is, however, the sandstone, in which it occurs in the three following positions:—

1st. Disseminated in minute fragments throughout the substance of the rock.

2nd. Coating the joints and fractures.

3rd. Occurring irregularly, as definitely-shaped pieces, which have resulted from the replacement of fragments of fossil wood, shells, &c., or the filling of cavities which have been left vacant by decomposition.

In the first position (disseminated through the rock) it is in very minute, irregularly-shaped fragments, which fill up the interstices between the grains of sand forming the sandstone, and presents the appearance of being the cementing material of the rock, although it has undoubtedly originated as a secondary infiltration. When slabs of the rock, abundantly infiltrated with this opaline material, are cut and polished the effect produced is remarkable, presenting a minutely kaleidoscopic effect, from the variegated play of colours which the individual pieces of opal possess. This opal, so far, is of no commercial value as a gem; but it might be largely utilised for inlaid work in jewellery, and for supplementing the internal decoration of buildings for which tiles and marble are now used.

In the second position (coating the joints and fractures) the layers of opal are, as a rule, of no great thickness, but its quality is generally fairly good, and it possesses to a considerable degree the play of colours which is so characteristic of the better varieties of this gem. Much of this joint-opal is so thin that it could only be used for inlaid work. There is, however, a considerable proportion of it which is of sufficient thickness to allow of its being cut and polished as gem-stones.

In the third position the opal occurs as definitely-shaped pieces scattered through the substance of the rock. In size they vary greatly up to a foot in length. This opal has originated in various ways, as follows:—

1st.—By replacement of fossil wood.

2nd.—By replacement of Invertebrate forms, chiefly Mollusca.

3rd.—By secondary filling of cavities formed by decomposition.

In many of the opals which have originated from fossil wood, the minute structure of the wood can still be detected, even by the naked eye, the fibrous tissue of the wood having, during its fossilisation, been replaced by opal-silica. In many specimens of opalised wood, where the entire thickness of a branch has been opalised, the major portion of this usually consists of dull milky-white common opal, the radial cracks from the centre being alone composed of clear opal showing a brilliant play of colours.

In the second form of replacement the entire substance of shells, segments of encrinite-stems, &c., have been converted into opal, in fact, complete opaline casts of mollusca have been obtained, whose surfaces show considerable play of colours. This is a remarkably rare form of the replacement of fossil mollusca by opaline matter. Already some of the more perfect specimens of opalised shells have been sold by jewellers at high prices. There is every reason to believe that this process has really been in most cases an actual replacement of the shell substance, and not merely a filling of a cavity formed by the disappearance of the shell by decomposition.

In many cases the opal shows no woody structure, nor does it present the shape of any Invertebrate form. It is probable that in some of these cases the opal has been deposited from solution in cavities which had been formerly occupied by fragments of wood, whose minute structure had not withstood the processes of fossilisation. The larger fragments, exhibiting no minute structure, are generally of a milky-white or honey-yellow colour, and do not show much play of colours; but many of the smaller pieces, which have evidently been formed in cavities left by the decomposition of individual fragments of wood, &c., are of good quality, and are tinged with bluish and purplish hues, presenting considerable play of colours.

Owing to the very irregular mode of occurrence of opal in the sandstones near Wilcannia, and the fact that it does not occur in defined lodes, the methods adopted to obtain it necessarily differ somewhat from ordinary mining operations. The outcrops of the sandstones are carefully searched for any traces of opal, and when these have been discovered the specimens are picked out by hand. No deep shafts are sunk, as in the case of mining for metals. The only positions in which

they are sunk (and that only a few feet) is where there is a joint carrying good opal, but the blasting of the rock enclosing the opal necessarily breaks up the specimens of the gem. There is, therefore, great difficulty in obtaining the opal from the sandstones, which are of considerable hardness. In other parts of the world it is usually obtained from the decomposed portions of volcanic rocks, from which it can be readily picked without the danger incurred by first having to blast or break the matrix enclosing it. There is no method of producing artificial decomposition of the matrix (such as is done at the diamond-mines in South Africa for the extraction of diamonds), because the rock is of so siliceous a nature that it is almost impossible to disintegrate it; in fact, at the exposed faces of the cliffs there is remarkably little sandy detritus resulting from the natural degradation of the sandstone. It, therefore, appears to me that the extraction of the opal from the Desert Sandstone is only possible in the immediate neighbourhood of the surface outcrops, but there are probably large areas of alluvial in the vicinity of the cliffs which might be rich enough in commercially valuable opal to repay working by the ordinary methods of auriferous alluvial mining.

VIII.—Note on the Intrusive Porphyry at Melrose: by P. T. Hammond, Field Assistant.

Although many localities are generally known in New South Wales in which the junction of highly-altered sedimentary rocks, with the igneous rocks which have probably caused their alteration may be observed, I am not aware that any have been placed on record. The examination of such junctions is of great geological importance, as we must rely principally on such evidence as this would afford to explain the origin of many rocks in New South Wales that have been considered elsewhere to result sometimes from extreme metamorphism of sedimentary beds whilst at others they occur as almost undoubted igneous rocks.

It is my intention to place on record such localities as may from time to time come under observation. A systematic list might subsequently be prepared, and would doubtless be of use in directing attention to these localities.

Very little systematic work has yet been done with regard to our igneous and metamorphic rocks, and the close examination of the boundaries of apparently intrusive rocks, at their junction with undoubted sedimentary beds would place beyond doubt the origin of such rock-masses.

Starting from the one-mile marked tree on the road from Melrose Homestead to Mount Tinda, Parish of Gindoono, County Cunningham, and going in a north-easterly direction, a section may be seen showing a gradual transition from the highly-inclined Silurian slates, striking N. 10° W. and S. 10° E., through all stages of metamorphism, till one arrives at the crest of a hill which appears to be the southerly extension of a spur from the main range which forms the northern boundary of the country; this hill lies to the south of Mount Susannah (a conspicuous hill in the same spur). Here an apparently eruptive porphyry has been intruded along the bedding planes of the Silurian strata, causing them to assume a porphyroid structure, simulating very closely the appearance of the eruptive rock itself, in which also a false-bedded structure has been induced in places by the lateral pressure of the associated strata.

This structure renders it difficult to distinguish the actual boundary-line of either rock, and this is only rendered possible in the field by the much greater lamination of the altered beds, which still retain much of their original structure, though some beds occur in which every trace of this has been obliterated.

Such beds resemble quartz porphyry, with both quartz and felspar porphyritically developed, and even felsite, while others just as highly altered, yet contain waterworn quartz pebbles, showing that they were originally conglomerates.

I have also observed an almost exactly similar rock to some of these beds, which still contains the casts of crinoid stems plainly discernible throughout its mass, putting beyond question its sedimentary origin.

This rock occurs on a hill on which some prospecting for silver has been done, situated about a mile and a half in a west-south-westerly direction from the thirty-mile marked tree on the Melrose to Condoubolin Road.

IX.—Idiographic Drawings of the Aborigines in a Rock-shelter at Weeny Creek, Colo River, near Richmond: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

UNDER the guidance of Mr. J. P. Collins, Head-master of the Superior Public School at Richmond, Hawkesbury River, and accompanied by Mr. C. T. Musson, F.L.S., an inspection was made of a Rock-shelter in a tributary gully of Weeny Creek, Colo River, about eight miles north-west of Richmond, and some three-quarters of a mile off the Comleroy Road.

The aboriginal name for these Rock-shelters appears to have been that of "Gibber-gunyas," literally, "houses of rock," at any rate, in the Port Jackson and Hawkesbury Districts. The late Mr. Surveyor Govatt, in describing the country between Port Jackson and Broken Bay,* refers to the shelters in the Hawkesbury Sandstone, on ridges dividing the Cowan and Berowra Creeks: "These caves, or hollows," he remarks, "are called by the natives gibber-gunyas, or houses of rock."

The Shelter near Richmond is situated on the bank of a small gully, and is of the usual type of those met with in Hawkesbury Sandstone country, hollowed partly by fluviatile action, partly by atmospheric influences, out of a long low escarpment of rock. The Shelter is twenty-five feet long, eleven feet deep, and eight feet high inside; but, on account of its dome-shaped interior, only four and a half feet at the entrance. The walls have been much defaced by vandalistic writings and smudgings, but the previous aboriginal contributions are still plainly visible. They consist of about a dozen hand-outlines of different sized figures of "Iguanas," one of them four and a half feet long, a flying squirrel, boomerangs, and a tomahawk, mounted on its handle, nine inches in length, all reproduced by splash-work. A good deal of touching up has unquestionably been done by visitors, but I have every reason to believe that the objects mentioned are genuine; indeed, the renovation simply consists in re-outlining the figures with charcoal.

This Shelter, with its drawings, has been known for fifty years. The late Mr. G. Day, of Comleroy, informed Mr. Collins that even then the drawings were beyond the knowledge of any of the local blacks.

The floor of the Shelter is stone, and in consequence there is no room for interments; neither is there any trace of hearth rubbish, leading to the belief that the recess had not been used to any great extent as one of residence.

Idiographic drawings have been known from the time of the earliest explorers, and are usually depicted either in black on the flat, or simply in outline. Flinders† refers to them, on the rocks of Chasm Island, Gulf of Carpentaria, in black and red on a white ground, representing turtles, kangaroos, and the human hand. Cunningham‡ described figures of sharks, porpoises, turtles, lizards, trepang, starfish, clubs, fish, and canoes done in white outline on a groundwork of red, on the roof and sides of caves at Clark Island, Cape Flinders.

The practice of hand-imprinting, almost universally distributed over Australia, appears to have had little attention paid to it, comparatively speaking. Mr. Alfred Howitt, in his "Notes on the Aborigines of Cooper's Creek,"§ says:—"Among the

* Sketches of New South Wales, No. XII. *Saturday Mag.*, 1836, IX, No. 284, p. 223.
† Voyages, ii, p. 158.
‡ P. P. King's Intertropical Coasts of Australia, 1827, II, p. 26.
§ Smyth's Aborigines of Victoria, 1878, II, pp. 300-309 [p. 309].

back-country blacks at the Barrier Ranges there is a custom of making 'rock-paintings.' That is, the figure of an outstretched hand, sometimes colored, sometimes plain on a colored ground. When the former, the hand is daubed with red ochre or pipe-clay and printed off. The latter mode is to place the extended hand on the rock, and to squirt color over it out of the mouth; on the hand being removed, the print is left on a colored ground." In Western Australia, according to Mr. H. Y. L. Brown,* the hands are blackened, and then pressed against the stone. He saw, remarks the late Mr. R. B. Smyth, "one cave in granite rock where there were many such figures of hands of different sizes, the form of each being cut out very neatly."

On the other hand, the late Mr. E. M. Curr considered such hand-imprints of no import, "unless it be the first step in imitative art."† He also remarked:—"As I have often myself seen the blacks imprint their hands stained with red ochre on suitable surfaces in this way, I cannot accept such marks as a proof of antiquity."‡

Although it is, of course, quite possible that to many of the later degenerate Aborigines hand-imprinting may have been simply a matter of sport and pastime, yet evidence exists of the antiquity of this practice, and it is of too much importance to be dismissed in this hurried and conclusive manner. It must not be forgotten that the habit, or even perhaps rite, of hand-printing on surrounding objects was in vogue with the ancient inhabitants of the Deccan, the Dravidians, from whom the Australian blacks are to some extent supposed to be descended. Such an affinity is further supported by the use of the boomerang, and many points of similitude in the two languages. Speaking of the Dravidians, Dr. A. Carroll says:—"They use projectiles like the Australian 'boomerang' . . . . . They made prints of a red hand on rocks, trees, &c."§ The same Author further remarks:—"Thus we find the 'stencilled or painted' hand in Australia pointing to the rites connected with evil deities . . . . and this same 'red hand' points to the Siwa and Durga worship in India, and the prevalence of these there, as do similar markings on the rocks, trees, &c., of this land."‖

The tribe at the mouth of the Leichhardt River marked their *Bora* grounds with peculiar signs, amongst others a hand painted on a conspicuous tree, with red ochre or blood, or chopped out of the bark;¶ and Flanagan even states that shields are at times ornamented with figures of hands, more particularly the shield known as the *Eleman*,** but I have not found any support to this statement.

* Smyth, *Loc. cit.* I, p. 291.
† Australian Race, 1886, II, p. 301.
‡ *Ibid*, 1887, III, p. 679.
§ Sydney Quart. Mag., 1889, VI, No. 2, p. 126.
‖ *Ibid*, No. 3, p. 206.
¶ W. E. Armit in Curr's Australian Race, 1886, II, p. 301.
** Aborigines of Australia, 1890, p. 84.

Mr. J. Bonwick describes* a cave at Rylstone, in which are the impressions of red hands, some with the forefinger cut off, others crossing one another. He remarks:—"Amongst the tribes of ancient Egypt, and monuments of the Peruvians and Mexicans, the red cap and red hand are common, and evidently refer to some universally-spread mystery, some lost freemasonry." The bottom of this cave is said to be "paved."

In West Australia these Shelters are known under the name of *Dumbun*, and one near York is thus described by the Hon. George Fletcher Moore, many years ago Advocate-General of that Colony:—"The only vestige of antiquity or art which has yet been discovered consists of a circular figure rudely cut or carved into the face of a rock, in a cavern near York, with several impressions of open hands formed on the stone around it. The natives can give no rational account of this. They tell some fables of the moon having visited the cave and executed the work. They have little curiosity regarding it, and pay it no respect in any way. In short, it appears as if it did not concern them, or belong to their people. . . . This rude carving at York may possibly be the last trace of a greater degree of civilisation proceeding from the north, and becoming gradually more faint as it spreads to the south, till it is almost entirely obliterated; or, again, it may be the only monument now left to speak of a former race, which has altogether passed away, and become superseded by another people."†

Whatever, therefore, is the nature of these pictorial hands, and however much opinions may disagree, they are, nevertheless, worth investigation—the very difference of opinion amongst Authors rendering them so. Too many facts cannot be collected, and this done, some generalisation of a definite nature may perhaps be arrived at. My Colleague, Mr. P. T. Hammond,‡ observed imprints in the Rock-shelters of Wollombi that he believed to be those of women or children, judging by their size. If his supposition be correct, it is exceedingly interesting, for the absence of hand-markings attributed to women has been commented on more than once. At the same time it must not be forgotten that the average male aboriginal hand was much smaller than that of the whiteman; witness, for instance, the the small hand-holes in the generality of their shields. Mr. Hammond further comments on the presence in the Wollombi Rock-shelter of one right hand, a very unusual occurrence, and still more so, that of feet. If done in sport, it seems more than probable that this was confined to the younger generations of blacks, who were quite ignorant, from their association with the whites—and, thereby, a loss of the pristine traditions of their race—of the esoteric meaning of these delineations, for a hidden meaning I believe they possessed. Dr. Carroll§ states that "comparative mythology has established the fact that the impression of the left

* William Buckley, the Wild White Man (8vo., Melbourne, 1856), p. 87.
† Descrip. Vocab. Language Aborigines W. Austr., &c., 1842.
‡ Records Geol. Survey N. S. Wales, 1892, II, Pt. 4, p. 175.
§ Centennial Mag., 1888, I, No. 8, pp. 189-191.

hand was the sign-manual of a wizard or sorcerer." He distinguishes several degrees of tribal importance in the representation of the hand. Thus the Wizard crest is "represented by the left hand stencilled or shaded upon the rock-shelters." The sign-manual of the Chief Initiators was a hand "wetted with blood, and the character impressed (not stencilled) upon the rocks." That of the Chief Elder "was a black hand, indicative of the power of declaring war, or even commanding the extermination of a tribe"; whilst the white hand was indicative of the Elder, "privileged to terminate a strife, and despatch the heralds with their 'message-sticks' to hostile tribes." He further points out that hand-symbols have been found on every continent of the globe, and amongst other peoples, the Dravidians in India. Of the wizard's hands, Dr. Carroll gives an excellent illustration, taken from Kangaroo Point, George River, near Botany Bay.

Little more than the hand is ever depicted of one limb, although Sir George Grey describes* the outline of a hand and arm painted black on a white ground on the rocks of the Upper Glenelg River, North-west Australia. This form of drawing is very rare.

X.—The Caves at Goodravale, Goodradigbee River; by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plates VII–IX.]

I.—Introduction.

THE following Notes are the result of a recent examination (January, 1892) of the Caves at Goodravale, on the Goodradigbee River, about six miles south of its junction with the Murrumbidgee, made by Mr. John Mitchell, of the Public School, Narellan, and the Writer, when engaged on a preliminary geological exploration of the Goodradigbee Valley as far as Wee Jasper, and the country in a north-easterly direction as far as the Bloomfield Crossing on the Murrumbidgee River.

II.—History.

The existence of caves at Goodravale has been known for many years, but with the exception of a brief remark by the late Rev. W. B. Clarke, F.R.S.,† "that the Coodradigbee (*sic*) caverns will repay research hereafter," and a reference by Mr. Charles Jenkins‡ to the fact that he had visited them, no other mention has been

* Journ. Two Exped. N.W. and W. Austr., 1837–39, I, 1849, p. 204.
† Sedimentary Formations of N.S. Wales. Third edition, 1875, p. 55; Fourth edition *ibid*, 1878, p. 104.
‡ Exploration of the Caves and Rivers of New South Wales (Minutes, Reports, Correspondence, Accounts), *N.S. Wales Parl. Papers*, 1882.—102 A (pp. 52, plates, f. cap, Sydney, 1882), p. 35.

made of these caverns, so far as we are aware. Mr. Jenkins was employed by the Trustees of the Australian Museum (Exploration of Caves and Rivers Committee) to examine the various Caves throughout New South Wales, a work that was not carried out, unfortunately, beyond those at Cave Flat, junction of the Murrumbidgee and Goodradigbee Rivers, and that only in a very partial and imperfect manner.

In one of his letters to the Committee, Mr Jenkins stated* that "there are a great many caves (at least a dozen) on the Coodradigbee (*sic*), most of which I have been in; some, however, have been discovered that I have not seen of any great length, as I learn with many ramifications." In another letter† to the same body he fixes the position of the Caves as "near the post in [Portion] 61, parish of West Coodradigbee," and adds, "one is larger than any of those I have yet explored."

III.—Locality.

Our examination was confined to two caves at Goodravale, occurring in a very large belt of limestone, extending from Cave Flat, on the Murrumbidgee, for many miles to the south. The most important of the two caves, and which may be appropriately called the Goodradigbee Cave, is situated about ten yards to the east of the south-east corner-peg of Portions 61–51, Parish of West Goodradigbee, County Cowley, and is therefore identical with that referred to by Mr. C. Jenkins (Plate VII). The second, or Goodravale Cave, as we propose to term it, is on Portion 51 of the same Parish, and is so much inferior to the Goodradigbee Cave that it will demand but a brief notice. In addition to these two caves, we found the entrances, three in number, to a third, and probably much larger cavern, situated on Portion 5, Parish of West Goodradigbee (Plate VII); but from the want of proper appliances, and our limited party, we were unable to descend the narrow, deep, and vent-like orifices leading to it.

IV.—The Caves.

1. THE GOODRADIGBEE CAVE.—The low entrance is situated on the limestone rise to the east, and above a small alluvial flat in the gully forming an arm of a large swamp extending over parts of Portions 3, 4, and 30, Parish of West Goodradigbee. A short inclined passage of a few feet leads to an irregular and more or less vertical descent of rather less than fifteen feet, which lands the explorer on the top of the descending talus of the first chamber (Pl. VIII, No. 1), which is here broad-oval in shape, but after narrowing, and the floor becoming level, broadens out into a fine expanse of about seventy feet wide.‡ It has a

* *Loc. cit.*, p. 30.
† *Loc. cit.*, p. 35.
‡ It must be distinctly understood that all the measurements are simply approximate. To arrive at anything like absolute accuracy in so intricate a place as a series of cave-chambers would entail much time and labour, and a detailed survey.

right- and left-hand portion, the latter much the larger and more important, with a rising block-strewn floor, culminating in a small daylight entrance, which can be reached by a little precipitous climbing. The stalactitic, stalagmitic, and stalacto-stalagmitic "formations" in both halves of this chamber are more massive than beautiful, although some delicate stalactites are visible on the roof and sides of the right-hand portion. The first to attract attention is a stalagmitic pedestal (Pl. VIII, *a*), at the point of enlargement of the chamber from the entrance. Other similar pedestals are scattered about, especially round the sides, varying from six feet and upwards in height; but the most important object in this chamber is a very fine stalagmo-stalactitic pillar (Pl. VIII, *b*), arising from the irregular rocky floor of the left-hand portion, and extending up towards the roof, through which a small stream of daylight enters. This pillar must be quite fifteen feet in height, if not more. From this left-hand section of Chamber No. 1 two passages are given off in a generally south-east direction, proceeding to the inner parts of the cave. For the sake of clearness and brevity, these passages may be denominated A and B respectively.

Passage A (Pl. VIII, A), but a few feet wide, descends for a short distance, at an angle of thirty degrees, and then ascends over a red-earth flooring, and with the limestone roof much frosted with incipient stalactites, opens into Chamber 2 (Pl. VIII, 2) a dry limestone cavern without "formation" except a huge mass of limestone and stalagmite immediately at the entrance (Pl. VIII, *c*), but a large quantity of red-earth deposit. This little chamber is about one chain in length, twenty feet wide, and perhaps fifteen high, the large mass at the entrance practically splitting it into two passages, rather than a chamber. This is succeeded by a short passage leading to another dry cavern, Chamber No. 3 (Pl. VIII, 3), similar to the last in character, but longer, and of a greater height, the roof graduating upwards into numerous crevices and cracks, some of them becoming funnel-like. Two short blind passages are given off at the end of this chamber, on the right hand, filled with quantities of red earth, but one of them has a drop or pit in the earth of some feet, and will be referred to again later on. The walls of Chamber No. 3 exhibit a grand display of outstanding weathered fossils, chiefly Corals and *Stromatopora*, similar to those observed by us in the "Hall" at Cave Flat.* Again, a brief narrow passage leads to an irregular small chamber, Chamber No. 4 (Pl. VIII, 4), from which a network of small blind and curved passages lead off, filled with red earth, one in particular, on the left, circling round on itself, and re-entering the chamber. All these small side passages are similar, just high enough for the explorer to traverse in a stooping position, and wide enough for one to pass at a time, irregularly filled with red earth, sometimes much, at other times little, frequently so far filling the passage that onward progress is only made by crawling over the heaps. In a few instances

* Australian Museum, Ann. Report of the Trustees for the Year 1888 [1889], p. 36.

diminutive chambers are met with in the course of these little passages, and when so the "formations" are excessively delicate and pretty. At the end of Chamber No. 4 the main passage takes a sharp turn, opening into a high and very irregular although not large cavern. Chamber No. 5 (Pl. VIII, 5), which has a large right-hand extension, almost at right angles, passes upwards, and is filled with large irregular blocks of fallen limestone and stalagmitic matter, resting on a very irregular floor, rendering the explorer's progress slow, rough, and difficult. The roof has several fantastic masses of limestone hanging from it, and there are a few cascade stalactitic formations. Some of the smaller stalactites are still active. At about one chain from the entrance to Chamber No. 5 rises an exceedingly beautiful stalagmitic pillar, which, from its elevated position on the rising irregular floor, and its glistening surface, presents a very imposing appearance. From the opposite end of Chamber No. 5, a short upward passage leads to another small almost-circular high-roofed chamber, No. 6, containing a small amount of stalactitic formation. At the upper end of the rising floor of this chamber is a downward perpendicular drop in red earth of eight feet (Pl. VIII, *e*), when the passage of communication is resumed, opening into the last chamber (Pl. VIII, 7). It is quite evident that the present red-earth floor of this chamber does not represent its true floor, but that the limestone walls descend some distance below this. At a height of five feet ten inches above the red-earth floor is a fine example of a stalagmitic floor, dividing the chamber into two parts, with, resting on it, a foot of red earth and pebble wash. It stands to reason that at one time this five feet ten inches of space was filled with red earth, which has been subsequently removed. Chamber No. 7 terminates in a passage choked with red earth, and through this we were unable to penetrate. The last few passages and two chambers exhibit traces of bat-dung, but bats themselves were not seen.

Having now arrived at the termination of the main roadway of the cave, or, as we have termed it, Branch A, in all about one hundred and seventy yards, in round numbers, from the actual entrance, we may return to Chamber No. 1, and trace the course of Branch B, in its general direction sub-parallel to Branch A. A gradually-narrowing passage leads to a very fine limestone cavern, Chamber No. 8, about one chain in length, and forty feet wide, containing a few stalactites, particularly a cascade-like mass at the entrance, and others at its further end, illustrating the columnar formation. On the left centre a branch is given off, with funnel-like upcasts high in the roof, containing traces of red earth adhering to the limestone sides, and ultimately communicating with Branch A. At the far end of this chamber, on the right hand, a tortuous winding course proceeds, sometimes passage-like, at others as a tunnel, or again a mere crevice, through which progress is with difficulty made, leading to a very small chamber (Pl. VIII, 9), containing four stalactitic floors, superimposed one above the other. The lowest is three feet above the cave-floor, and those above about four feet apart. Through

these we descended, as through the storeys of a house. From this little chamber a descending passage leads to a lower level, and terminates in a funnel-shaped upcast (Pl. VIII, *f*), through which a large quantity of the red earth has evidently descended from the surface.

Returning to Chamber No. 9, we continued our course along a small curving passage, bifurcating right and left (Pl. VIII, *g*), the latter portion opening into a second small chamber (Pl. VIII, 10), containing a few brown columnar stalactites. At this point a further bifurcation takes place, when, by returning back, as it were, on the left, along a similarly narrow passage as before, but well lined with small stalactites, of more or less beauty, the explorer will arrive at another small almost-circular chamber, with a highly acicular roof, and connected with a passage leading from the right of Chamber No. 8.

Returning to the small Chamber 10, and passing up the right-hand branch, a pit in the red earth is met with, about ten feet deep. This leads to a lower passage, ultimately joining Branch A, leading from the first large chamber. On returning to the right-hand branch, after leaving Chamber No. 9, a similar narrow passage is traversed as before, and the rocky head of Chamber No. 5 is entered, above the fine stalagmitic pillar already referred to (Pl. VIII, *d*). It is evidently supported on a stalagmitic floor, for near its base is a small hole, between limestone blocks, and partially filled with red earth. This leads into a hollow space or chamber under this floor, the base of the large pillars being clearly discernable. The pillar itself is a grand exemplification of the mode of formation of such stalagmitic accumulations. The whole surface is covered with small semi-lunar or crescentic oblique cups or basins, formed by the deposition of the lime from innumerable small drip-spots above, the pillar being by no means the result of deposition from a single large stalactite. At the head of this branch of Chamber No. 5 there is another of the drops or sudden descents, of some feet in depth—about eight feet—communicating with the tortuous passages leading to Chambers Nos. 9 and 10, afterwards curving round on itself, and then communicating with Chamber No. 3.

2. THE GOODRAVALE CAVE.—This is situated on the northern extension of the same outcrop of limestone on Portion 51, Parish of West Goodradigbee.

The entrance is gained by clambering down the steep side of a large broken-in chamber (Pl. IX, 1), now almost wholly open to the day, with blocks of limestone and the remnants of a few stalactites scattered about it. The deeper recess of this chamber narrows to a small archway (Pl. IX. *a*), a good deal obstructed by fallen material, and ushering the visitor into a rather smaller and longer chamber (Pl. IX, 2) which has two branches, a right and a left. The former is completely blocked, except an airway immediately under the roof, with a bank of dry red

earth (Pl. 1X, *b*). There can be no question that were this deposit cleared out, other and more defined chambers could be reached. The left-hand branch becomes passage-like for some distance, when it divides, the left-hand branch terminating in a small rather triangular chamber (Pl. IX, 3). The main passage here contains a good deal of red and black earth, and bat's dung, the black earth being the result of the admixture of the red deposit and the dung. A good many stalactites and stalagmitic masses are present, but very dirty, and formation is still going on. The limestone exposed in this cave is highly fossiliferous, the mode of weathering of the component corals resembling that at Cave Flat, and in Chamber No. 3 of the Goodradigbee Cave. Although disappointing, both from its size and dirty state, it is probable that the Goodravale Cave would yield pleasing results if the red-earth deposit could be systematically removed, and the passages and chambers followed out.

3. OTHER CAVES.—If the limestone escarpment be followed in a southerly direction from the Goodrabigbee Cave, many surface-depressions, indicating fallen-in chambers, and small entrance-holes, with intake air-currents may be noticed. One in particular occurs on Portion 5, and is indicated by three deep natural shafts in close contiguity to one another, one perhaps forty to forty-five feet deep, and a second probably about sixty feet. The absence of proper appliances and sufficient assistance prevented our exploring these vertical descents. Their position is approximately shown on Pl. VII.

V.—General Remarks.

The general direction of the strike of the Goodravale Limestone is N. 20° W., and a glance at the plan of the Goodradigbee Cave (Pl. VIII) will show that it approximately follows the strike, whilst the Goodravale Cave (Pl. IX) does so in a somewhat less-marked manner. Both caves consist of a series of large and small chambers, united by passages in some cases of fairly large size, at others narrow, low, and tortuous. They may possess plain limestone walls, or here and there be frosted with small stalactites, which render bodily abrasions on the part of the explorer moderately frequent. Some of these passages have small lateral recesses filled with delicate and elegant stalactitic formation.

I think little doubt can exist that the chambers primarily owe their origin to the action of surface-waters percolating through cracks and crevices along the strike, and by imperceptible degrees dissolving away the limestone, thus enlarging any small natural cavity which may have existed, until space is gained for more vigorous action. That these caves do not represent an underground watercourse, strictly in the sense of a creek-flow, is, I think, certain; but they chiefly acted as surface-drainage channels through cracks and fissures. This appears self evident

when the position and nature of the red-earth deposit is considered. It is nothing more than disintegrated and decomposed limestone, and whenever roof crevices and funnel-shaped upcasts are searched by the aid of the magnesium lamp, they will invariably be found choked with this deposit. Facts of this nature have been referred to in more than one instance during the previous description of the several chambers. That considerable bodies of water entered these caverns is also clear from the stratified nature of the deposit, and especially the presence of the pebble-wash in Chamber No. 7 of the Goodradigbee Cave, associated with the stalagmitic floors. The latter are very remarkable, and illustrate in a general way the number of more important inrushes of sediment that have taken place. Similar floors are described in the Belubula Caves by the late Mr. C. S. Wilkinson. The position of the small mouth of the Goodradigbee Cave is such, above the level of the wide alluvial flat, bordered by the limestone escarpment, that an immense body of water would be required to fill the valley before an inroad could be made into the cave. I believe that many of the caves throughout New South Wales, where there is no definite trace of an underground creek, have been formed in this way.

It is seldom that the visitor walks on the actual limestone bottom of the chambers or passages in the present caves, but usually on a deposit of red-earth or stalagmitic flooring, the tread in the latter case generally giving rise to considerable resonance. To display these chambers in their true size and grandeur would necessitate the removal of hundreds of tons of red earth now filling them.

VI.—Age of the Deposit.

The only means we possess of forming even the crudest idea of the age of the infilling of our caves with the red-earth as a deposit, is by means of their fossil contents—in other words, are the bones generally associated with the latter of living or extinct species? The Rev. W. B. Clarke mentioned the occurrence of bones of the Emu,* but whether of the existing or extinct species (*Dromaius patricius*, De Vis), there is no means of ascertaining. This solitary instance seems to be all that is definitely known of fossils from these caves. Mr. Jenkins has left no evidence that he collected any, although it is possible that he did, for we find the Curator of the Australian Musuem remarking†:—"I am fully convinced that no fossil bones of any value are being obtained in the Coodradigbee (*sic*) Caves." As Mr. Jenkins was recalled, just as he was about to start work at the Goodradigbee Caves, it is probable that the bones referred to were those obtained at Cave Flat, for anyone not acquainted with the district would be very liable to confound the one set with the other.

* Sedimentary Formations of N. S. Wales—Fourth Edition, 1878, p. 104.
† Exploration of the Caves and Rivers of New South Wales, &c., *loc. cit.*, p. 36.

So far as the limited time at our disposal enabled us to form an opinion, the Goodravale Caves do not contain any extended deposit of fossil bones. We had, however, the singular good fortune to unearth one of the large carnassial teeth, attached to a portion of the ramus, of *Thylacoleo*, the Marsupial Lion, in all probability *T. carnifex*, Owen. This was found under a small shelf of stalagmite, when working our way in the small passage, leading from under the large pillar in the right-hand extension of Chamber No. 5 (Pl. VIII, *h*), round towards Chamber No. 3 of the Goodradigbee Cave. The occurrence of this one genus will be quite sufficient to place the age of the red-earth deposit, at any rate its lower portions, on a par with that of the Wellington Caves, with a copious extinct fauna; the Jenolan Caves, in one of which was found the almost entire skeleton of a *Thylacinus*, a genus now quite extinct in Australia; and the Bone Cave at Cave Flat, wherein Mr. Mitchell and the Writer discovered the largest skull of *Thylacinus* known.*

* Australian Museum, Ann. Report of the Trustees for the year 1888 [1889], p. 36.

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. III.] 1892. [Part 2.

XI.—On the Geological Occurrence of the Broken Hill Ore-deposits: by E. F. PITTMAN, A.R.S.M., Government Geologist.

DURING a recent visit to Broken Hill, I had an opportunity of inspecting the under-ground workings of several of the principal mines, and was impressed by some facts in connection with the geological occurrence of the lodes which appear to be of general interest.

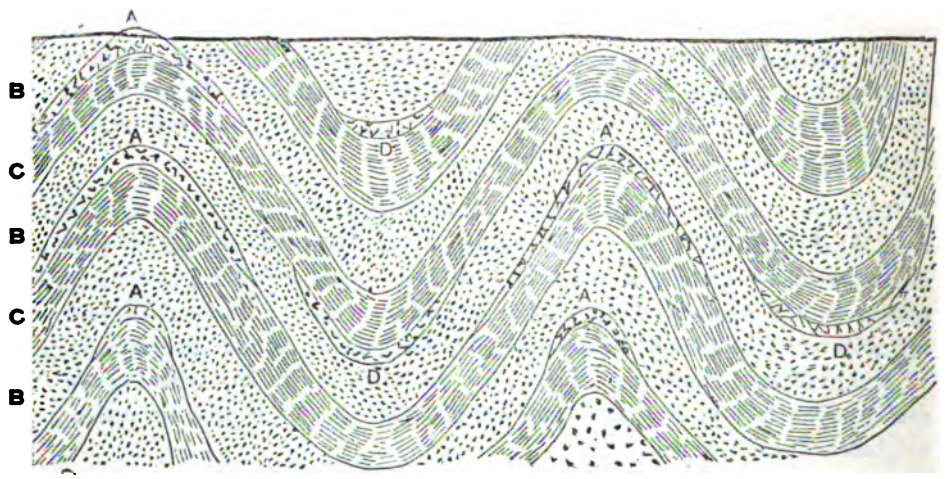
The principal impression conveyed to my mind is that the Broken Hill Ore-deposits do not occur in what is known as an ordinary true fissure lode, but should be referred to what are called "segregated lodes," of the type known in the Bendigo District (Victoria) as "saddles."

It is true that the "saddle reefs" of Bendigo (Sandhurst) differ materially from the Broken Hill Lode in dimensions, in metalliferous contents, and in the character of the gangue or veinstuff—the first named consisting of auriferous quartz with a small percentage of iron pyrites, while the Broken Hill Lode is argentiferous (though containing some gold) and consists, at and near the surface, of manganiferous ironstone, which below is replaced by kaolin and oxidised ores (carbonates) of lead, and these are again, at greater depths, succeeded by sulphides of lead and zinc.

Nevertheless, there are points of similarity between the two which are worthy of note, and which may have some bearing upon the probable persistence in depth of the Broken Hill Ore-deposits.

The difference (according to J. A. Phillips) between a true fissure vein and a segregated vein consists in the fact that the former occupies a fissure, cutting (in a direction which may be more or less oblique) across the bedding planes of the country rock, while the latter is deposited in a fissure formed between and parallel with the stratified beds; the ore, in fact, having filled the space caused by the forcing apart of two contiguous beds. The variety of segregated veins, so well known in Bendigo, as "saddle reefs," and which, so far as I know, have not been hitherto recorded as occurring in any mining country except Victoria, differs from ordinary segregated lodes, merely in the fact that instead of lying in one plane, they occupy spaces or fissures which, owing to the bending or contortions of the country rocks, have assumed somewhat the shape of an inverted trough, and in cross section have the appearance of a saddle—hence the name.

The country rock at Bendigo consists of highly contorted slates and sandstones which are of Lower Silurian age. The contortions of these slates and sandstones have assumed the forms of anticlines and synclines. If a quire of paper be placed flat upon a table and lateral pressure be exerted against the sides, it will be found to form saddles and troughs, or anticlines and synclines, corresponding with the contortions of the Bendigo rocks, which have in fact been produced in an analogous manner, and it will be noticed that spaces will be formed between the sheets of paper, more particularly at the upper parts of the anticlines and the lower parts of the synclines, corresponding exactly with the fissures in which the saddle reefs of Bendigo were deposited.

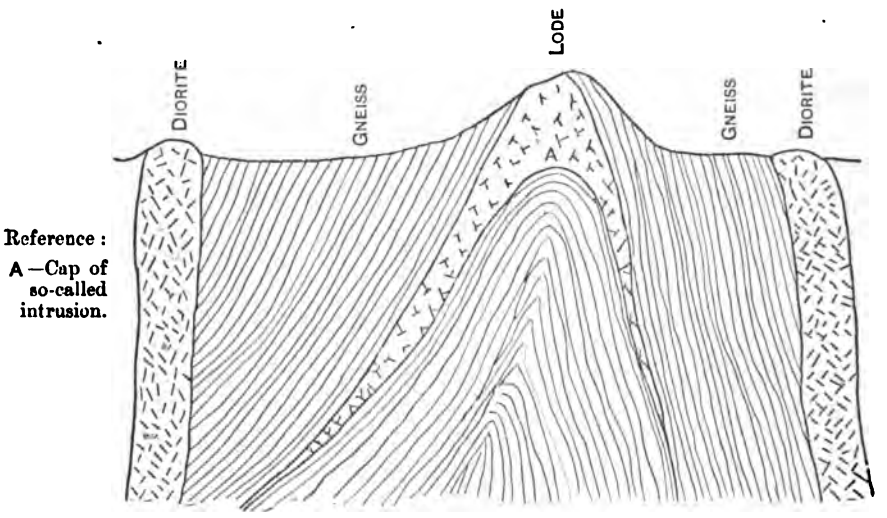


A—Saddle reefs. B—Sandstone. C—Slate. D—Inverted saddles.

The reefs at Bendigo are associated with narrow intrusive dykes of dark grey dolerite, which probably have had some influence upon their auriferous contents.

One of the chief points of interest about the saddle reefs of Bendigo is, that while the "legs" of the saddles are invariably found to thin out and disappear in depth, the permanence of the mines is assured by the certainty of other saddles being discovered almost perpendicularly under the first, and at greater or less intervals of depth.

Now the Broken Hill District is composed of similarly contorted rocks, consisting principally of crystalline gneisses passing into banded quartzites, micaceous and hornblendic schists, and garnetiferous sandstones. Owing to the highly altered character of these rocks, and the consequent absence of organic remains, it is difficult to determine their exact age, but they were considered by the late Mr. C. S. Wilkinson, F.G.S., to be at least as old as Lower Silurian, and probably older. There are no dolerites in the neighbourhood of the mines, but intrusive dykes of highly basic diorite are seen extending along both sides of the hill and more or less parallel to it. Broken Hill itself is composed of an anticline, the highest part of the ridge being occupied by the outcrop of the lode—a mass of manganiferous iron ore which has withstood denudation by reason of its hardness and compactness—while on the eastern and western slopes of the hill the gneissic rocks are found to be dipping east and west respectively. Below in the mines the lode is found to divide into two portions, one following the eastern dip, while the other and larger portion dips to the west. The depth at which the lode divides differs in the different lodes along the hill. The rock which separates or divides the lode into the eastern and western portions is locally referred to by some as the "horse," and by others as the "intrusion," but it appears to me that both terms are incorrect and misleading. It is not an intrusion, because it has not the character of a volcanic or intrusive rock, but consists in some places of gneiss, and in others of banded quartzite, both similar in character to the rocks to be seen at the surface. A "horse" consists of a mass (of greater or less extent) of country rock which has fallen from the hanging wall into the vein fissure before the latter was filled with mineral. But the character of the rock forming the so-called "horse" at Broken Hill shows that it has not fallen into the fissure, and been subsequently surrounded by lodestuff, but that it is the country rock or footwall of the lode *in situ*. In short, the foliations of this rock, which appear to coincide with its bedding planes, are clearly defined, and appear to indicate that it is the cap of an anticline, forming the lower walls of a saddle-shaped fissure which the lode has filled, and similar in formation to the curved beds of slate and sandstone which separate the legs of the saddle reefs at Bendigo.



Ideal Section of Broken Hill.

It has already been stated that this so-called "intrusion" is found at materially different depths in the principal mines along Broken Hill, and herein is another point of similarity to the Bendigo saddle reefs, which rise near to the surface in some mines and descend to greater depths in others, owing to the fact that the country rocks in which the reefs occur are contorted into curves along their line of strike as well as in the transverse direction.

The Broken Hill Lode, in short, appears to be a huge saddle lode, formed in a fissure which owed its shape to the contortions which the gneissic rocks have undergone. If this opinion be correct, the probability is that the eastern and western legs will be found to thin out gradually as they descend, and in that case the depth at which they would disappear would depend to a great extent upon the width of the synclinal basins on either side of the hill. The underground workings in Block 10 show that at a depth of over six hundred feet the western leg is still represented by a huge width of sulphide ores, so that the possibility of the lode thinning out is evidently not a matter for immediate alarm. What appears, however, to be the most interesting question is the possibility of similarly shaped lodes being found more or less vertically under the present one, as they are found to occur in Bendigo, and undoubtedly the best means of ascertaining this would be to put down diamond drill bores through the cap of the so-called intrusion.

The conclusions which I have endeavoured to convey, and in forming which I was assisted by the work already performed by Mr. Geological Surveyor Jaquet, may be summarised as follows:—

(1) In several important respects the geological formation and origin of the Broken Hill Lode and the saddle reefs of Bendigo appear to be analogous.

(2) If this analogy hold, the eastern and western legs of the Broken Hill Lode may be expected to thin out in depth.

(3) There is a possibility of other similarly shaped lodes being found more or less vertically underneath the Broken Hill Lode, and this could best be tested by putting down diamond drill bores through the cap of what is locally known as the "intrusion."

XII.—The Pentameridæ of New South Wales: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plates X and XI.]

I.—Introduction.

THE protean genus *Pentamerus* is represented in the Siluro-Devonian rocks of New South Wales, by six species, as follows:—

Pentamerus australis, *McCoy.*
„ Knightii, *J. Sby.*
„ linguifer, *var.* Wilkinsoni, *Eth. fil.*
„ ? costatus, *Eth. fil.*
„ hospes, *Barrande.*
„ pumilus, *De Kon.*

In the Upper Silurian of Victoria by one species—
Pentamerus australis, *McCoy.*

In beds of a similar age in Tasmania *apparently* by three species—
Pentamerus Knightii, *J. Sby.*
„ galeatus, *Dalman.*
„ tasmaniensis, *Eth. fil.*

The Middle Devonian of Queensland contains one species—
Pentamerus brevirostris, *Phill.*

Of these, by far the most interesting is *Pentamerus Knightii*, or at any rate the form which has been assumed to represent that species. It is as equally characteristic of a well-marked calcareous horizon in our Siluro-Devonian rocks as it is of the Aymestry Limestone in the British Upper Silurian. The shell affords an admirable key to this horizon at many wide-spread localities, as, for instance, at the Fish River, or Jenolan caves; Yarrangobilly Caves, near Kiandra; Goodravale

Caves, Goodradigbee River; Forest Reefs, near Orange; Bungonia Caves, Shoalhaven District; and Quedong, near Bombala, at most of which it occurs in abundance, and often of very large size.

II.—History.

In 1867 Professor Sir F. McCoy named*, and in 1878 described † his *Pentamerus australis* from the Upper Silurian of the Parish of Yerring, Upper Yarra, Victoria, which appertains to the group of *P. oblongus*, J. de C. Sby., and probably represents the latter in Australian rocks.

In 1882 I described a peculiar form of the genus from the Tasmanian North-west Coast Conglomerates,* and on a portion of which, as a basement bed, the well-known Tertiary beds of Table Cape repose. To this shell, a small but definite ally of *P. Knightii* also, I gave the name of *P. tasmaniensis*.

The late Prof. de Koninck referred two *Pentameri* in the Rev. W. B. Clarke's Collection to the European *P. Knightii*, J. Sby., and *P. oblongus* J. de C. Sby.,† from the Conobolas and Duntroon, New South Wales, respectively; and he further named a third species from Yass, believed to possess Devonian affinities, as *P. pumilus*. The so-called *P. oblongus*, is quoted by Mr. Charles Jenkins, L.S., from his Hume division of the Yass Upper Silurian; ‡ and by Mr. John Mitchell from Limestone Creek, near Bowning,§ in beds of a similar horizon. It is more than probable that the shell referred to by Mr. Jenkins, and certainly Mr. Mitchell's, is the *Pentamerus australis*, M'Coy. Mr. Mitchell also mentions ‖ another shell, a "deeply corrugated *Pentamerus* of triangular shape, that I have not yet identified, and which appears to be typical of this zone." This is referred later on to *P. hospes*, Barr.; whilst Mr. R. M. Johnston's *P. Knightii*,¶ from the Brachiopod Sandstone of the Queen River, Tasmania, and his *Pentamerus galeatus*** from the same horizon, have every appearance of being those species. Lastly, I have described†† from Queensland a well-marked Devonian *Pentamerus*, viz., *P. brevirostris*, Phillips, from the Fanning Limestone, Burdekin Downs.

This completes the published record of our Australian *Pentameri*. To them, however, must be added a very interesting form, to which my attention was first directed by Mr. Mitchell, his specimens being afterwards supplemented by others collected by us at Goodravale, Goodradigbee River, and now termed *P? costatus*.

* Ann. Mag. Nat. Hist., 1867, XX., p. 201.
† Prod. Pal. Vict., Dec. v., 1878, p. 28, t. 47, f. 9-12.
* Proc. R. Soc. Tasmania for 1882 [1883], p. 159.
† Foss. Pal. Nouv.-Galles du Sud, Pt. 1, 1876, p. p., 30, 31, and 94.
‡ Proc. Linn. Soc. N. S. Wales, 1878, III, Pt. 1, p. 26, t. 6, f. 8.
§ Proc. Linn. Soc. N. S. Wales, 1887, I (2), Pt. 4, p. 1198.
‖ *Loc. cit.*, p. 1198.
¶ Syst. Acc. Geol. Tasmania, 1888, t. 7, f. 10.
** Syst. Acc. Geol. Tasmania, 1888, t. 7, f. 10*a*.
†† Geol. and Pal. Queensland and New Guinea, 1892, I, p. 67, t. 37, f. 6, 9-11.

I have omitted from consideration the *Pentamerus oblongus*, said by the late Rev. J. E. T. Woods,* to have been found years ago in the Mount Lofty Chain, thirty miles south of Adelaide, as it requires confirmation.

III.—Notes on, and Description of the Species.

Genus.—PENTAMERUS, *J. Sowerby*, 1813.

(Min. Con., I, p. 73*).

Pentamerus australis, M'Coy.

Pentamerus australis, M'Coy, Prod. Pal. Vict., Dec. V., 1877, p. 28, t. 47, f. 9–12.
? „ *oblongus*, Jenkins (*non* J. de C. Sby.), Proc. Linn. Soc. N. S. Wales, 1878, III, Pt. I, p. 26, t. 6, f. 3.
„ „ Mitchell, *Ibid*, 1887, I (2), Pt. 4., p. 1198.
„ „ Mitchell, Proc. Austr. Assoc. Adv. Sci., 1888, I, p. 294.

Obs.—*P. australis* may be looked upon as an Australian representative of the European and American *P. oblongus* . . . . which it strongly resembles in size, shape, and surface. It is, however, perfectly distinguished by the inarching of the septa of the entering valve, and the large ovate rostral space so defined in the casts (*M'Coy*).

Both Messrs. Jenkins and Mitchell, as before noticed, have recorded the occurrence of a *Pentamerus* in the Bowning beds, referred by them to the European *P. oblongus*.

As regards Jenkins' shell, the figure is not sufficiently complete to allow a definite opinion to be formed, but it seems to be M'Coy's species. The shells, provisionally named *P. oblongus*, by Mr. Mitchell, I have seen, thanks to his kindness, and these are, in my opinion, nothing more than *P. australis*, M'Coy, from the May Hill Sandstone, of Yering, Upper Yarra District, Victoria. They possess the same longitudinally ovate and slightly convex form, with the surface unornamented, except by a few concentric undulations. On the other hand, the New South Wales examples are certainly smaller than the Victorian. In passing, a comparison may be instituted with *Pentamerus Knappi*, Hall*, but this will be found to be radiately costate in the centre of the valves. I have not seen the shell from Duntroon, named *P. oblongus*, by De Koninck,† and therefore refrain from including it in the above synonomy, but I suspect that it will prove to be *P. australis*, M'Coy.

* Geol. Obs. S. Australia, 1862, p. 20.
† Foss. Pal. Nouv.-Galles du Sud, Pt. I, 1877, p. 31.

It is difficult to understand from Mr. Jenkins' remarks to what portion of his "Hume" Series this species belongs; but in the corresponding "Bowning" Series of Mitchell, it is clearly met with in the lower portion of his Lower Limestone, at the base of the "Bowning Series."

Loc. and Horizon.—Silverdale, Limestone Creek, near Bowning (*J. Mitchell*); lower part of the Lower Limestone of "Bowning" (Hume) beds. Yass River, near junction with Boonu Ponds, near Yass (*C. Jenkins*); the fifth division of the "Hume" beds.

PENTAMERUS LINGUIFER, *J. de C. Sby.*

P. linguifer, var. Wilkinsoni, *var. nov.*

Pl. XI, Figs 5-9.

Pentamerus galeatus, Mitchell (*non* Dalman), Proc. Linn. Soc. N. S. Wales, 1887, I (2), Pt. 4., p. 1203.

" " Mitchell. Proc. Aust. Assoc. Adv. Sci., 1888, I, p. 294.

Sp. char.—Shell sub-globose, usually inflated, and as a rule wider than long. Ventral valve much curved, depressed above and thickened about the umbonal region; sinus very shallow, wide, flattened, and bounded on each side by a slightly raised fold; front deflected, produced, sometimes becoming almost perpendicular to the longer axis; lateral portions of the valves broadly rounded; umbo incurved, the sulcus commencing as a very shallow, almost imperceptible groove quite from the apex; vascular system (on internal casts) possessing two main trunks, arising in the umbonal cavity, and shortly bifurcating, with a lateral branch proceeding down each flank and central branches on either side of the shallow sinus, each portion again dividing near the front; septum comparatively short. Dorsal valve transversely ovate, wider than long; tripartite subdivision frequently highly marked, arising from a strong development of the mesial fold, which is confined to the anterior half of the valve, impressed by a faint median groove, and, when seen from the front, squarish; when viewed in profile the valve is convex from the umbo until the fold commences to rise, whence it is concave to the front margin; front margin sinuated, the central emargination rather straight-sided. Surface of the valves with a few laminæ of growth, otherwise smooth.

Obs.—I first became acquainted with this interesting variety many years ago, in a small collection of fossils sent to me for identification by my late friend Mr. C. S. Wilkinson, Government Geologist, and then regarded it as *P. linguifer*. It resembles both *P. linguifer*, J. de C. Sby., and *P. globosus*, Barr., and in a less degree *P. galeatus*. Like *P. globosus*, Barr.*, our species possesses two plications on the ventral valve, and a flat sulcus between them, but they are absent on the

* Syst. Sil. Bohêmiæ, 1879, V, t. 24, f. vi.

dorsal valve, and thereby differ from Barrande's species. The plications are replaced in our shell by the ordinary rounded folds of the dorsal valve. The septum is also much smaller. On the exterior of the dorsal valve only one septum is visible; but, that this will not invalidate the reference to *Pentamerus* is shown by the occurrence of the same feature in Dr. Davidson's figure of *P. linguifer*†, and Barrande's *P. optatus*.‡ Some specimens of our shell, again, are not unlike *P. pelagicus*, Barr§.

I do not trace any great resemblance to *P. galeatus*, Dalman, the high umbo of the ventral valve, and semi-costate nature of the surface of this species separating it from *P. linguifer*, var *Wilkinsoni*. On the other hand, there is a close relation between the latter and *P. linguifer*, J. de C. Sby**, even to the flattened or depressed umbo of the ventral valve, but the appearance of the fold and sinus in the two differs considerably and may be used for varietal separation. For a long time I hesitated whether to consider the Australian shell as a variety of *P. linguifer*, or a separate species. On the whole, it seems to be intermediate between *P. linguifer*, J. de C. Sby, and *P. globosus*, Barr., and to represent the two species in Australia, just as *P. australis*, M'Coy, does the shells of the *P. oblongus* group. *Pentamerus subglobosus*, Meek and Worthen††, has a similar inflation of the front to the var. *Wilkinsoni*, but the valves are otherwise comparatively smooth. *P. fornicatus*, Hall‡‡, is also rather like the latter, but is, judging from the figures, too deltoid a form.

The square-fronted straight-sided fold and sinus, seen in so many examples of *P. linguifer* var. *Wilkinsoni*, is exhibited by Davidson's Fig. 11*b*§§; the depressed umbo of the Australian variety is visible in his Fig. 11; whilst the general form of the ventral valve of the new variety is displayed in Fig. 13*b*, of the same author. There are occasional instances, however, in which the inflated round-shouldered appearance presented by Davidson's Fig. 11*a* is visible amongst our specimens. In short, *P. linguifer*, var *Wilkinsoni*, exhibits the same amount of variation *inter se* that the species in chief does, and on the same lines; but it differs from the latter in its peculiarly flattened ventral sulcus, and other minor characters. As before said it seems to occupy an intermediate position between *P. linguifer*, and *P. globosus*.

Through the kindness of Mr. John Mitchell, I have examined the *Pentameri* obtained by him from the various beds of his Bowning Series, as indicated in the synonomy, and I find the form recorded by him as *P. galeatus* from the lower

† Mon. Brit. Sil. Brach., 1867, Pt. VII, No. 2, t. 17, f. 11 and 13.
‡ *Loc. cit.* t. 24, f. v. (5c., 6c. and e.)
§ *Loc cit.*, t. 23.
** Davidson, Mon. Sil. Brach., 1867, Pt. VII, No. 2, p. 149, t. 17, f. 11-14.
†† Illinois Geol. Report, III, p. 423, t. 13, f. 6*a*.
‡‡ Pal. N. York, 1852, II, p. 81, t. 24, f. 7 *a-d*.
§§ *Loc. cit* t. 17.

portion of his Lower Limestone to be the present variety, an identification in which Mr. Mitchell now coincides. The same remark applies also to the *Pentamerus* recorded by him from his Lower Trilobite bed. This is the upward limit of *P. linguifer*, var. *Wilkinsoni*, according to Mr. Mitchell's section; and in all probability it will coincide with the horizon given in Prof. T. W. E. David's section of the Yass Upper Silurian, extending from the Bald Hill Creek to the Reedy Creek*, although a thorough unanimity does not appear to exist in the sequence of the beds as laid down by the authors in question. According to Prof. David, a *Pentamerus* occurs at Hatton's Corner, Yass River, in dark greenish brown shales, "possibly a continuation of the shale beds at Limestone Creek, which yield fine specimens of *Phacops caudatus*, and *Phacops longicaudatus*." This *Pentamerus*, from specimens at present before me, is *P. linguifer*, var. *Wilkinsoni*; the shale so rich in Trilobites is probably the "Phacops bed" of Mr. Chas. Jenkins†, and the Middle Trilobite bed of Mr. Mitchell, but, according to the notes obligingly supplied by the latter, the particular shells in question come from his Lower Trilobite bed, hence the discrepancy.

Loc. and Horizon.—Junction of Limestone and Barbour's Creeks, near Bowning (*J. Mitchell*); Lower Limestone, Bowning Series. Limestone Creek, near Bowning (*J. Mitchell, T. Ramft*); Lower Trilobite bed, Bowning Series (*Mitchell*). Hatton's Corner, Yass River (*J. Mitchell*); Lower Trilobite bed, Hume Series,‡ Quedong, Delegate River, three miles below junction with Bombala River, County Wellesley (*C. Cullen*); horizon undetermined.

I regard the Bowning horizon as portions of the Wenlock Formation, and, by analogy, those at Quedong containing this species will probably be of the same age.

PENTAMERUS KNIGHTII, *J. Sowerby.*

Pl. X, Figs. 1-6; Pl. XI, Figs. 1-4.

Pentamerus Knightii (J. Sby.), Davidson, Mon. Brit. Sil. Brach., 1867, Pt. vii, No. 2, p. 142, t. 16, f. 1–3, t. 17, f. 1–10, t. 19, f. 3.

„ „ De Koninck, Foss. Pal. Nouv.-Galles du Sud, 1876, Pt. 1, p. 30,

Very large Pentamerus, Mitchell, Proc. Linn. Soc. N.S. Wales, 1888, I (2), Pt. 4, p. 1198.

Pentamerus Knightii, Johnston, Syst. Acc. Geol. Tasmania, 1888, t. 7, f. 10.

Sp. Char.—Shell elongately triangular, both valves much arched longitudinally, extending towards the front, becoming more or less geniculate, especially the dorsal valve, and the surfaces of both evenly convex. Ventral valve narrow and

* Ann. Report Dept. Mines N.S. Wales for 1882 [1883], Sections 1 and 3.
† Proc. Linn. Soc. N.S. Wales, 1878, III, pt. 1, p. 25.
‡ Hume Series of Jenkins—Bowning Series of Mitchell.

laterally compressed in the visceral region, expanding towards the front, the frontal margin being very sinuous, convex at the sides, emarginate in the middle; umbo pointed, much incurved, and overhanging a high and narrow sub-umbonal space, or false area; fissure long, not wide, and generally much exposed; septum very long, extending almost to the front margin, and almost vertically truncated, its double laminæ thick, and, when separated, the transverse, curved, sub-imbricating growth ridges well marked; divergence of the dental plates slight, growth ridges on them sigmoidally curved; middle or V-shaped chamber narrow. Dorsal valve short, broadly triangular, generally very much smaller than the ventral, and frequently displaying a considerable amount of geniculation; umbo not prominent, but deeply inserted in the fissure; lateral margin emarginate, front margin convex, but no perceptible trace of a fold; hinge plates very long, extending nearly to the front. Surface of both valves with numerous simple or furcate costæ, except to a large extent on the flanks of the ventral valve, and slightly so on those of the dorsal, where the costæ are absent and the flanks smooth, except a few wide undulations of growth, which cross the valves generally.

Obs. The foregoing description has been wholly drawn up from Australian specimens, and will enable a critical comparison to be made with the European forms of the species. Our variety of *P. Knightii* acquired large dimensions, although the average size is two inches long, and at the front of the valves one and a half inches wide. In the caverns of the Yarrangobilly, and Goodravale Caves, I have seen natural sections of the shell four and five inches long, which is quite equal to the largest examples of *P. Knightii*, of the Aymestry Limestone, in the West of England.

No more characteristic species occurs in our "Siluro-Devonian" Limestones than *P. Knightii*, as evinced by the twelve localities given below, and I am in the belief that it chiefly characterises a certain horizon.

From a morphological point of view, the most valuable point of difference between the European and Australian forms of *P. Knightii* lies in the further forward extension in the latter of the ventral septum, and the septa of the dorsal valve, features which impress themselves most strongly on the observer when viewing natural sections of the valves on rock surfaces, as at the Goodravale and other caves.

It is worthy of remark that our form appears to differ in precisely the same manner amongst its own individuals as the European does; for instance, some occur (Pl. X, Figs. 2 & 4) with the flanks, particularly of the ventral valve, devoid of costæ, precisely similar to Dr. Davidson's Pl. 17, f. 1a. The latter figure also shows the high, outstanding, although incurved umbo, which compares well with that shown in our Pl. X, Figs. 1, 2, & 4. In other cases the umbo is much more depressed.

We also possess the oval variety represented by Davidson in his Pl. 17, Fig. 5, and the transverse form (Davidson, Pl. 17, Fig. 4) is a most marked one in New South Wales, especially at Quedong, where nearly the whole of the specimens are of this shape. Variation also takes place in the costation, small individuals, and probably also young forms, possessing very much finer and comparatively close set costæ (Pl. X. Figs. 5 and 6.)

The valves of our *P. Knightii* are at times very geniculate, more so than any figured by Dr. Davidson, so much so on the part of the dorsal valve, that the latter does not wholly face its fellow ventral, but partially only; and the line of union of the two valves is not parallel to the longer axis, but to a greater extent transverse to it. This will be manifest on examining Pl. X. Fig. 4.

The late Dr. Davidson seemed to think *that very little difference existed between *P. Knightii*, J. Sby, and *P. vogulicus*, V. and K.† Outwardly the resemblance is a very close one, but the growth ridges on the septum of *P. vogulicus* run directly across it, and are not at all sigmoidal as in *P. Knightii*. On the other hand the ridges on the dental plates of *P. vogulicus* are gently sigmoidal. The structure is confirmed by the figures of the Russian species given by Mr. Von Gruenewaldt in his "Fossils of the Silurian Limestone of Bogosslowsk."‡ In our species the structure of these plates is as in *P. Knightii*.

Again, so far as external appearances are concerned, a very close resemblance exists between the Australian *P. Knightii* and *P. conchidium*, Dalman, as figured from Cornwallis Island, Arctic Regions, by Salter.§ But the striation in the latter more nearly resembles that of *P. vogulicus*, and it is the type of a section of *Pentamerus* only, characterised by a small deltidium, but of which there is no trace in our form.

As *P. Knightii* possesses with us great stratigraphical importance, it will be necessary to closely investigate the various horizons at which it has been found; suffice it to say, at present, that it does not seem to have been noticed by Jenkins in his Yass or Hume beds, but Mitchell mentions a "very large *Pentamerus*" on the horizon of *Euomphalus Clarkei*, De Kon, in the upper part of the Lower Limestone. This is *P. Knightii*.

In the typical Upper Silurian area of Wales and Western England, *Pentamerus Knightii* is the characteristic fossil of the Aymestry (or Ludlow) Limestone, although it occurs sparingly in the underlying Wenlock, and overlying Upper Ludlow, but not sufficiently to become a distinctive fossil of either series. It would appear,

* Mon. Brit. Sil. Brach., 1867, Pt. VII, No. 2, p. 144.
† Géol. Russie d'Europe, 1845, II, t. 7, f. 2, *b*.
‡ Mém. Sav. Étranges, St. Petersbourg, 1854, VII, t. 4 (separate copy), f. 14 *d*.
§ Sutherland's Journal Voy. Baffin's Bay and Barrow Strait, 1852, II, App., p. ccxxv, t. 5, f. 9 and 10.

therefore, that we also possess limestones equally characterised by *P. Knightii;* and it will be interesting to ascertain whether or no such deposits occupy a homotaxial position to that of the Aymestry Limestone in the Silurian Series of Europe. In the meantime, I purpose calling the beds in which *P. Knightii* predominates with us the Pentamerus Limestones.

Localities.—Jenolan or Fish River Caves, near Oberon, Co. Westmoreland (*T. W. E. David*, B.A. &c.); Bungonia Caves, near Marulan, Co. Argyle (*L. Guymer*); Forest Reefs, near Orange, Co. Bathurst (*E. O'Shea*); Walli, fifteen miles from Cowra, Co. Bathurst (*G. S. Evans*); Kerr's Creek, Calloola Mts., Co. Bathurst, (*Australian Museum*); Limestone Creek, near Bowning, Co. Harden; (*J. Mitchell, T. Ramft*); Goodravale Caves, Goodradigbee River, Co. Buccleuch (*R. Etheridge, Jun.* and *J. Mitcheil*); Yarrangobilly Caves, near Kiandra, (*W. S. Leigh, R. Etheridge, Jun., V. Wiburd*); Biddenluke, Co. Wellesley; Quedong, Delegate River, three miles below junction with Bombala River, Co. Wellesley (*C. Cullen*); Mount Canobolas, Co. Bathurst (*L. G. de Koninck*); Calalamine (*L. G. de Koninck.*)*

PENTAMERUS HOSPES, *Barrande.*

Pl. XI, Figs. 11 and 12.

Pentamerus hospes, Barrande, Syst. Sil. Bohême, 1879, V., t. 20, f. 11 *a-g*, t. 24, f. VIII, *a-b.*

Obs.—Imperfect examples of a *Pentamerus*, collected by Mr. J. Mitchell in the Bowning District, are clearly allied to three Bohemian species—*P. hospes*, Barr., *P. sulcifer*†, Barr., *P. firmus*, Barr.‡, but more particularly to the first named.

P. hospes is a triangular shell, the two others rather less so; all strongly arched longitudinally, particularly the ventral valves, and bearing sharply angular, coarse, regular, simple, radiating costæ. The Bowning examples also indicate a very triangular convex-valved shell, bearing similar costæ, but these seem to bifurcate here and there. The greatest affinity appears to exist with *P. hospes*, and I shall content myself by referring the Bowning specimens to that species, provisionally, until we are better acquainted with their more complete structure.

Of the five specimens in existence four seem to be the ventral valve, and the remaining one the dorsal. The outline of the ventral valve is strongly triangular, with the flanks either vertical or concave, as in *P. Knightii.* The costæ vary from six to ten in number, and are strong, angular, and complete as a rule, but in two instances they are seen to bifurcate. The interspaces or valleys are deep and open. There are traces on one specimen of concentric, sub-imbricating, moderately close laminæ.

* I am unable to trace this locality, unless it be Coolalamine Plain, locally called "Coolaman," between the Goodradigbee and Cotter Rivers, Co. Cowley, mentioned by Clarke (S. Goldfields, 1860, pp. 86 and 104.)

† Syst. Sil. Bohême, 1879, V., t. 9, f. vii, *a.c.*

‡ Syst. Sil. Bohême, 1879, V., t. 9, f. viii, *a.c.*; Ibid., t. 79, f. ii, *a.b.f.h.*

The dorsal valve appears to be less triangular and broader, as is often the case in the genus *Pentamerus*.

The ventral septum extends for about one-third the length of the valve exteriorly, whilst the dorsal septa are rather shorter.

The resemblance to *P. hospes* is increased by the presence in the latter of close concentric laminæ similar to those visible on one of our specimens. Next to *P. hospes* the latter resemble *P. sulcifer* rather than they do *P. firmus*.

Loc. and Horizon.—Junction of Barbour's and Limestone Creeks, near Bowning (*J. Mitchell*); Lower Limestone (Wenlock) of the Bowning Series.

PENTAMERUS? COSTATUS.—*Sp. nov.*

Pl. X, Figs. 7 and 8, Pl. XI, Fig. 10.

Sp. chars.—Shell small, longitudinally oval. Ventral valve longitudinally arched, high in the umbonal region; umbo acute, rather incurved; false area high and triangular; fissure large, extending from immediately under the umbo-apex to the hinge line; the latter shorter than the width of the shell, with well rounded alar angles; sinus very well marked, deep, channelling the umbo to the very apex; front margin deeply emarginate in the middle line; dental plates short; V-shaped, or central chamber, small; costæ strong and simple, two prominent ones bounding the sinus, followed by two or three more on each side.

Obs.—For this interesting form we are indebted in the first instance to the careful researches of Mr. John Mitchell, who collected examples some years ago at Goodravale, Goodradigbee River. During a recent visit to that locality we mutually succeeded in obtaining additional specimens, some showing traces of the internal characters.

The only species with which I have been able to effect a comparison is the previously mentioned *Pentamerus hospes*, Barrande,* with which our form agrees in its outline, and coarse, few costæ, but differs in the possession of the exceedingly well-marked sinus. *P.? costatus* is possibly allied to *P. tasmaniensis*, mihi,† from the Table Cape Conglomerate, Tasmania, but the want of the external shell in the latter renders it difficult to arrive at a satisfactory conclusion. However, there is no trace in *P.? costatus* of the rugged, terrace-like, concentric laminæ visible in *P. tasmaniensis*, or the deflected front and sides and consequent cuboidal outline.

In external appearance *P.? costatus* is not unlike some *Spiriferæ*, a likeness which is heightened by the shape of the mesial sinus, but so far as the material in my possession at present enables me to judge, the general facies of the species

* Syst. Sil. Bohême, 1879, V, t. 24, f. viii.
† Proc. R. Soc. Tasmania for 1882 [1883], p. 159, t. 2, f. 1, 3-3.

is more that of *Pentamerus* than of *Spirifera*, more particularly when the internal structure is examined (Pl. XI, Fig. 10.) This figure, representing a natural ventral section from the umbo forwards at about one-third of the distance into the interior, shows the short median septum and the dental plates enclosing the V-shaped or middle chamber.

Loc. and Horizon.—Limestone Escarpment, Portion 51, Parish of West Goodradigbee, Co. Buccleuch (*J. Mitchell* and *R. Etheridge, Jun.*); Pentamerus Limestone ("Siluro-Devonian").

PENTAMERUS PUMILUS, *De Koninck.*

Pentamerus pumilus, De Koninck, Foss. Pal. Nouv.-Galles du Sud, Pt. 2, 1876, p. 94, t. 3, f. 3, 3*a*.

Sp. Char.—Shell subglobular. Ventral valve very regularly convex; umbo small, although very strongly recurved, projecting beyond the hinge line. Dorsal valve nearly as deep as the ventral, although slightly sinuated in the middle line; front margin slightly sinuous. Valves ornamented with fifteen slightly-curved anguiar costæ, quite simple and without furcation, the middle costa of the ventral valve being rather larger than the others and quite straight; the costæ are separated by well marked deep valleys. (*De Koninck.*)

Obs.—I have not seen this species. There are no characters indicated in Prof. De Koninck's description which would satisfactorily demonstrate it to be a *Pentamerus*, but in the illustration, Fig. 3*a*, there is every indication of an open fissure into which the dorsal umbo seems to protrude.

Loc. and Horizon.—Neighbourhood of Yass (*The late Rev. W. B. Clarke*); black compact limestone of supposed Devonian age, probably one of the Upper Silurian limestones displayed in Prof. T. W. E. David's section.

GENUS CYRTINA, *Davidson*, 1858.

(Mon. Brit. Carb. Brachipoda, p. 66.)

Cyrtina carbonaria, *M'Coy.*

Cyrtina carbonaria, var. australasica, *Eth. fil.*

Cyrtina carbonaria, M'Coy, var. australasica, *Eth. fil.*, Proc. Linn. Soc. New South Wales, 1889, IV (2), Pt. 2, p. 210, t. 17, f. 6–8.

Obs.—In a small collection of Permo-Carboniferous fossils, made in N. W. Australia by Mr. W. W. Froggatt, for the late Sir W. Macleay, and now in the Macleay Museum, I detected a variety of the typical Carboniferous shell, *Cyrtina carbonaria*, M'Coy, and gave to it the varietal name of *australasica*. A description will be found at the above reference.

Cyrtina septosa, the commoner of the two British species, has already been determined from a New South Wales locality by the late Prof. De Koninck,* but *C. carbonaria* was unknown to me from this Colony until an opportunity was afforded, through Prof. T. W. E. David, of looking over a few fossils collected by Mr. F. B. Gipps from the neighbourhood of Cape Hawke, and associated with *Productus cora*, d'Orb., and a *Leptodomus*, the latter probably new.

Mr. Gipps' specimen has lost the whole of the shell, except at the back of the umbo, and on the shoulders of the ventral valve. It is now, with this exception, an internal cast, with the impressions of the coarse radiating costæ visible towards the front, and the ventral septum is also preserved. The sinus was shallow. So far as the specimen goes, it coincides with the form of the above variety, and may, I think, be accepted as indicating its occurrence in New South Wales.

Loc. and Horizon.—Neighbourhood of Cape Hawke, Co. Gloucester (*F. B. Gipps.*)

XIII.—Geological Notes on the Swamp Oak and Niangala Gold-fields: by G. A. STONIER, F.G.S., Geological Surveyor.

I.—General Physical Features.

SWAMP Oak is partly in the Parish of Loftus, and partly in that of Ainsley, Co. Parry, and is distant from Tamworth twenty-five miles, a few degrees south of east, while Niangala is nine miles further in a south-easterly direction, and situated in the Parish of Walcha. Both places are within the watershed of the Swamp Oak Creek, which rises in the Great Dividing Range, and, flowing in a north-westerly direction for fifteen miles, turns to the west and joins the Mulla; it is then known as the Cockburn, runs into the Peel River a couple of miles to the east of Tamworth, and flows into the Darling through the Western Plains.

Swamp Oak Creek is intermittent, although water can always be obtained by sinking, but the Mulla is permanent, and when the former is dry, the latter is a strong flowing stream.

The physical features of the two districts present marked differences.

Swamp Oak Township is two thousand four hundred feet above sea-level by Aneroid levels, and is situated on a gentle well-grassed slope, which was formerly used as a "Top Station" for the Swamp Oak Creek Station. The surrounding country is mountainous, and consists of well-timbered hills, having rocky and in places almost precipitous sides.

* Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 116, t. 15, f. 2, 2*a*.

Niangala is situated on a table-land, and by barometer levels, three thousand five hundred feet above sea-level. The water-parting of the Great Dividing Range occurs a short distance easterly, and is sharply defined. The table-land continues easterly for some miles, but the western fall is soon broken, in places very abruptly. The table-land forms part of the New England Table-land, and presents only slight undulations as a result of erosion.

II.—Geology.

The formations developed may be classified as follows:—

(1.) Recent Alluvium.—Quaternary. } Cainozoic.
(2.) Basalt. } Tertiary. } Cainozoic.
(3.) Tertiary Alluvium. } Tertiary. } Cainozoic.
(4.) Diorite.
(5.) Granite.
(6.) Serpentine.
(7.) Mudstones, sandstones, &c., more or less altered.—Lower Carboniferous (?)

(1) *Quaternary.—Recent Alluvium.* As the various watercourses are chiefly confined and have precipitous sides, there has not been the opportunity for the accumulation of large areas of alluvium. The patches, which have been formed, are isolated, and consist chiefly of quartz-sand and pebbles, more or less rounded, of the altered mudstones. Gold has been obtained since 1852 in Swamp Oak Creek; and at the present time in the Cockburn River, particularly after rain, pieces weighing up to five pennyweights can be obtained. In Swamp Oak Creek, from its junction with the Mulla almost to its source, grains up to half-a-pennyweight are found. As a rule the gold is shotty and differs entirely from the fine gold that is obtained from the reefs, so that the older river courses may perhaps be found to contain coarse gold. Several of the alluvial patches are worth a trial, but, as the water is strong, the work will be attended with some difficulty.

(2) *Basalt.*—This formation occurs in oval patches near Niangala, and towards Walcha occupies a large tract of country, and furnishes the regularity of outline which is characteristic of the New England Table-land. It consists of a coarse olivine-dolerite, well crystallized and rich in olivine. The older alluvials, to which reference will next be made, underlie the basalt.

(3) *Tertiary Alluvium.*—About a mile and a half north-west from Niangala, an outcrop of drift has been discovered, and a couple of shafts sunk, which show the wash to be several feet in thickness and of a bouldery nature. The pebbles consist chiefly of quartz and altered slate with several quartz boulders up to two feet in diameter. Colours of gold are said to have been obtained, but the work

done has not been of a character to test the lead at any one spot; it is certainly worthy of further attention. Between Niangala and Walcha there is a large area occupied by basalt, which overlies in places old water-courses. These leads may be difficult to trace, and in places wide, but they are likely to carry payable deposits of gold where they have traversed auriferous strata, and should repay the time devoted to prospecting. It is difficult to fix the exact age of the lead discovered at Niangala, as Palæontological evidence is not available, but it is probably contemporaneous with the wide-spread leads at Nundle. In the latter the width of the channel which contains the auriferous drift has not been proved. The superficial alluvium is ten chains wide in places, so that it is not easy to locate the position of the deepest ground. An important point, too, is the occurrence of a bar which runs parallel to the course of the channel, and to the north of Nundle has increased the difficulty of determining the position of the wash-dirt. It is not to be inferred that the same width of alluvium will be found at Niangala, but the occurrence is mentioned to emphasise the necessity of the leads being properly tested before they are pronounced to be valueless.*

(4.) *Diorite.*—This rock occurs on both fields in a well-marked axis of upheaval, and is of the utmost importance, as it has probably occasioned the veins and furnished the precious metal.

At Swamp Oak the axis runs north-west, the dyke being well defined, and varying from eight feet up to a chain in width. From the cemetery, near the New Year Gift Mine, it can be traced in an almost unbroken line northerly, until it crosses the Swamp Oak Creek, then turns slightly to the west, and after a short break opposite the Rising Moon Battery, can readily be followed to the Mystery Lease, when turning almost at right angles for a short distance, is then lost. Overlapping this line, and a few chains westerly, another dyke starts at a gully to the south of the Victory Tunnel, and goes northerly to the Mystery Shaft, where it turns to the west, and, crossing the Highland Mary Lease, passes to the west of the Nelson Blocks, and across the northern corner of the Recreation Reserve. No attempt was made to trace it further either north or south, but it doubtless continues in both directions, and, in prospecting towards Nundle or Walcha Road, should be an invaluable guide. There do not appear to be any parallel or cross dykes. On the Carbine Block there is a patch, a chain and a half square, which is probably a boss indicating the existence of a much larger mass underneath, of the same age as the dyke. Doubtless other dykes occur, either outcropping, or at some little depth below the present surface, and it must be remembered, that, since the intrusion of the diorite, a considerable time has elapsed, and the country has been subjected to extensive denudation.

* For information on the Nundle Leads, see a "Report on the Hanging Rock and Nundle Gold-field" by the late Mr. C. S. Wilkinson. *Ann. Report Dept. Mines N.S. Wales for* 1888 [1886], p. 182.

At Niangala the dyke is not so wide as at Swamp Oak, nor does it make so bold an outcrop, but it can readily be traced from the Golden Spur Mine to the Jersey Lily Claim. Its width is difficult to determine, but does not exceed twenty feet. Immediately to the south of the Golden Spur it does not appear to outcrop, nor has any vein been discovered in the same direction.

The dykes are classified as later than the granite, because the country between the two auriferous zones has undergone alteration, and is traversed by quartz-veins which are not auriferous, while at Swamp Oak there is evidence that a vein resembling those referred to, has been reopened and become gold-bearing. These facts appear to find their explanation in the influence of the diorite belt, and not of the granite, and to justify the proposed classification, although the evidence is not clear enough to establish the later age of the diorite.

The direction of the Swamp Oak dyke bears N. 20° W. The upheaval does not appear to have been violent, as reversals or even flexures of strata are not distinguishable, and only such fissures as were inevitable have been developed.

The rock is holocrystalline, but varies in degree of crystallization, and at Niangala appears macroscopically to be a felspar-porphyry. But, under the microscope, it is seen that the only primary mineral present of any importance, whereby to determine the rock species, is felspar. Both orthoclase and triclinic felspar are developed; the latter predominates. It is clear from the fractured state of the crystals that the rock has been subjected to stress prior to its final consolidation. A ferro-magnesian mineral has been present, and is quite replaced by mica, with a little chlorite, epidote, and actinolite (?). Probably it has been amphibole, and there seems to have been an interaction between it and the felspars. Some magnetite is also present, but there is neither olivine nor quartz. It is clear that the rock belongs to the intermediate type, and as there are both monoclinic and triclinic felspars it should perhaps be classed as a syenitic-diorite. The specific gravity of a specimen from Swamp Oak, determined at the Sydney Mint, is 2·881, and of one from Niangala 2·924.

5. *Granite.*—Granite occurs in the form of a dyke, averaging about thirty-five feet wide, of felspar porphyry, and is found on the eastern extremity of the auriferous belt at Swamp Oak. It is well defined, and can easily be traced. It starts at G. L. 58, and crosses the Commotion Lease, runs to the east of the Carbine, and just within the western boundary of G. L. 67, and continues in a direction N. 30° W. about ten chains to the east of the north-eastern corner of the Rainbow Lease.

The rock is compact, with a slightly slaty-grey base, in which the felspar crystals are well defined, and of a yellowish white tint. Some of these felspars weather a reddish-brown and have much of the appearance of orthoclase, but many

are unaltered and are probably oligoclase, as they show fine lineation; hornblende and primary and secondary mica are also present. To the east of Niangala is found the western limit of the New England Table-land granite which outcrops also near Paradise.

The intrusion of the granite has crumpled the beds on the western side for a width of twenty-two yards.

6. *Serpentine.*—A large mass is found to the west of the Mulla in the Parish of Ogunbil with characteristically irregular and dirty brown outcrop, bold in places, and forming prominent rocky faces with scanty vegetation, and, at the flanks of the hills, yielding rich alluvial soil, caused by denudation of ultra-basic rocks. Its width is about a mile, and the eastern boundary bears north by west. The mass thins in a northerly direction, and it is doubtful if it can be correlated with either the Moonbi (Beedle's) or the Black Jack outcrop. From Barraba the serpentine can be traced for a long distance in a southerly direction, but, on approaching Tamworth, it thins, so that the Mulla area may be an inlier.

At Barraba it would appear that, the occurrence of gold is dependent upon the serpentine, which, so far as proved, has not had the same influence in the Nundle District. The question, however, cannot be looked upon as settled, and it is important that veins near the junction of the serpentine with the sediments should not be neglected.

That the serpentine at Barraba, is an intrusive rock* is evident both from the junction-line seen in the large sections, as well as in a hand specimen which was secured by Professor David during our trip through New England in March, 1891.

7. *Lower Carboniferous Mudstones, &c., more or less altered.*—The sediments occupy a very large area in both fields, and consist of mudstones, sandstones, &c., more or less altered, occuring, in the unaltered state, in small patches only. It is, however, the occurrence of these patches, as well as the similarity of the beds generally to much of the sedimentary area in New England, which has induced the proposed classification. That it is open to question is admitted; but after repeated observations the Author has come to the conclusion, that a large area in New England† may ultimately be referred to the Lepidodendron Series, which is considered to be Lower Carboniferous.‡ In going hurriedly over the section it is difficult to trace any break from the beds under consideration to those belonging, without doubt, to the Lepidodendron Series; at Barraba, also, the unaltered rocks can be followed into beds altered, as are some of the Niangala rocks, with independent cleavage, &c., there being no apparent break in the sequence.

* Mr. W. Anderson in a "Report on the Bingera and Barraba Gold-field" (*Ann. Report Dept. Mines N. S. Wales for* 1888 [1889], p. 182) says that this rock is in all probability an altered peridotite, which in the unaltered state was intruded amongst the slates.

† Ann. Report Dept. Mines N.S. Wales for 1891 [1892], p. 261.

‡ R. Etheridge, Jun., Records Geol. Survey N.S. Wales, 1891, II, Pt. 3, p. 119.

The metamorphism to which the rocks have been subjected is selective. Prior to the formation of the reefs, some of the beds have been opened for a certain distance along their strike, and this has allowed the percolation of silicified waters. Thus the alteration has been patchy. In some cases it appears to have been more intense close to the western side of the reefs, and there the rock ranges in a short distance from a claystone up to a quartzite. Speaking generally, the amount of silicification to which the rocks have been subjected has been great, and quartz-veins penetrated them in all directions, some following, and others cutting across the bedding planes at various angles.

At the junction of both the diorite and the serpentine with the sediments the immediate contact beds have been altered, but there appears to have been little opposition to the passage of these eruptive rocks. The granite, however, has caused not only silicification on a large scale, but for twenty yards on the western side of the granite dyke at Swamp Oak, the rocks have been contorted, the plications varying in width from a sixteenth of an inch upwards. The contortion has been accompanied by the infiltration of silicified water, which has passed into the opened bedding planes and deposited silica, which now appears, as if interbedded. The contortion of slate in the district was noted by the late Rev. W. B. Clarke in 1852. The occurrence is by no means uncommon in the northern district.

As a rule the dip is obscured by jointing and cleavage planes, and, it is only in odd places, that the lines of stratification can easily be distinguished. At Swamp Oak Township the general strike is N. 15° W., with a dip to the west at 37°, increasing in a westerly direction. On the Storm King line of reef the rock is a greenish grey argillite, in which the jointing is well marked, and might be mistaken for stratification planes, and is known to the miner as "greasy back." In the same series, but nearer Tamworth, there are sections which show clearly the obliteration of bedding planes in favour of jointing. At the Mystery Lease, the sediments have been more shattered than at any other portion of the field, and trenches several feet in depth, fail to touch the undecomposed and compact rock. Between Swamp Oak and Niangala, the rocks are more argillaceous, and as cleavage is developed they approach the slates in structure, but there does not appear to be a development of fissile slates. At Niangala the thin-bedded character of the mudstones can be seen in the Golden Spur Mine, but the section is not continuous over any large area, and cleavage again predominates.

The whole series is seamed with quartz, but it is only in the vicinity of the diorite dykes that the veins carry gold. At Swamp Oak, the auriferous belt is two and a quarter miles long, and one and a half miles wide. Immediately to the north and south of this area, there have not been any auriferous veins found, but as the tract of country is more or less of the same geological formation, there is

reason to believe that payable quartz reefs will be found, and it is a matter of importance that the country should be well prospected between Nundle and the Swamp Oak Creek, and also from Swamp Oak Creek in a northerly direction, until the granite is met. There is every likelihood that outcrops of diorite will be found, and the sediments in the immediate vicinity should be carefully examined for the veins.

III.—Mining.

(1.) *Swamp Oak.*—In the immediate vicinity of Swamp Oak, various reefs have been discovered, and the lines of reef have been named from the claim where the find was originally made. In very few cases, however, has a reef been found which, undoubtedly, extends into an adjoining claim. The reason for the difficulty in following the outcrop is at present doubtful, but the available evidence goes to show that the walls of the various fissures close, rather than that there is a complicated system of faulting. The Storm King is the only one which can claim to be a line of reef, and in this instance it seems likely that the intrusion of the diorite has caused a series of fissures, extending in one general line, and not one main fissure. There is evidence, however, that some of the gold-bearing veins are of later formation than others, and it may even be possible, when the field is further developed, to reduce the veins, as has been done in Cornwall, to two distinct systems.

Most of the veins, which have been worked, dip towards the dyke, *i.e.*, easterly, and later than these, there have been formed a series of veins which, where opened, are almost vertical, and have faulted the flatter veins. The latter carry a fair body of quartz and payable gold, but, where the former have been cut, their walls are actually in contact. It is probable that, in places, these walls open and allow the formation of shoots of auriferous quartz, but it is impossible at present to estimate the depth at which it may be expected. The question is one which must ultimately be met, and the sooner a solution is arrived at, the better it will be for the whole line of reef. In future prospecting, it is important that the vertical veins should be tested, to ascertain—(1) if they turn either to the east or west, in which case a body of "stone" will make—(2) the depth at which the faulted reef will be again met. The fault is a strike fault, and a body of stone will be found which does not show any surface outcrop.

The auriferous belt contains a number of veins, running chiefly north and south, and varying a few points to both the east and the west. The veins all carry mispickel more or less, and if the stone be crushed, roasted, and panned off in the ordinary fashion, will be found to carry gold. The feature of the quartz is the presence of mispickel, giving near the surface the light yellow stains which accompany the best "shows" of gold, and at a depth, the bluish tint, which is its characteristic. In almost any reef, where the quartz is blue, gold is present, and the reason why

various reefs appear to lose the gold, is, because it is in combination with the mispickel, from which, however, it can be freed by roasting. In prospecting any reef it is essential that the powdered stone should be thoroughly heated, until fumes cease, before an attempt is made to pan off the free and freed gold.

The mispickel occurs as small, isolated, and well-formed crystals, scattered through the vein-stone, even where there is no sign of a joint, so that it must have crystallized out before the solidification of the quartz; the percentage is generally about one and a half.

The quartz is compact, vitreous, and of a dark and slightly bluish-grey tint, so that the free gold is readily distinguishable. The gold is fine, somewhat resembling the mispickel in its occurrence, and appears to be a primary mineral, not solely resulting from decomposition of the pyrites. Iron pyrites is exceptional, but galena is found crystallized in small cubes on the Alpine line of reef, and associated with zinc-blende.

The Storm King amalgam retorts to two-fifths, the Highland Mary three-sevenths, and the Rising Moon one-third. After deducting Mint and Escort charges, the gold is worth £3 11s. 1d. per ounce.

Notwithstanding the facts that the field was discovered more than eighteen months ago, the deepest shaft is only one hundred and twenty-five feet, and it is a pity, that a more decided attempt has not been made, to prove the field in depth; for, it cannot be urged, with the number of encouraging proofs that have been unearthed, that there has not been sufficient inducement to properly test the veins. The work done proves that the gold will be found to run mostly in shoots, through which it is unevenly distributed. The rich shoots so far discovered, have not exceeded twenty feet in width, although, in several cases, the stone on either side has been sufficiently rich to pay for stoping. The average thickness is from nine inches to a foot, the veins themselves running up to three feet. Several of the claims have not attempted to prove the width of the shoots. Apparently, the fact of gold being in the shaft, is held to be the sole desideratum. The distance between the shoots, and also their dip, vary considerably.

(2) *Niangala.* The reefs discovered at Niangala resemble, in many respects, those found on the sisterfield—Swamp Oak. The quartz carries mispickel in the same form, perhaps in rather greater abundance, and the reefs owe their origin to exactly the same forces exerted, probably at the same time; so that, the one set of veins cannot be looked upon as younger than the other: for they traverse sediments which are of the same geological age. Microscopic sections show that the diorite is of the same kind as the Swamp Oak rock, but the dyke itself is not so wide, nor can it be traced either with the same ease or for the same distance. Owing to this distinction there is not a general line of reef similar to the Storm King, neither are there as many leaders running in various directions.

The veins are well defined, and do not appear to have been subjected to any complicated system of faulting; but there is evidence of a fault with a throw of about forty feet, which should not give much trouble. The deepest shaft is one hundred and ten feet, and the work already done shows that the rich parts will be found to run, chiefly, in shoots as at Swamp Oak.

A detailed reference to the mines will be found in the Annual Report of the Department of Mines and Agriculture of N.S. Wales, for 1892.

XIV.—Report on a Visit to the Narrangullen, or Cavan Cave, Taemas, Murrumbidgee River: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plate XII.]

I.—Introduction.

THE Narrangullen Cave, as it is locally called, or Cavan Cave, as termed on the Colony Map published in connection with the "Reports of the Royal Commission on the Conservation of Water," was examined in January of this Year, by Mr. John Mitchell and the Writer, under rather disadvantageous circumstances, chiefly arising from difficulties of approach to the cave and distance from our base of operations. Our examination was not, under these circumstances, of that minute nature we should have liked it to be. This is the more to be regretted from the fact that the chambers of the cave are traversed by an underground creek. The Narrangullen Cave would well repay another and more minute exploration.

II.—Locality.

The three entrances to the Narrangullen Cave are situated at the foot of a steep hill of limestone, about thirty yards on the western side of the boundary between the Parishes of Narrangullen and Taemas, Co. Cowley, on Portion 1, within the former parish, and, as near as we could locate it, opposite to Portion 49 of the latter parish. Below the hill, on the side whence the entrances lead inwards, is a small alluvial flat forming a *cul-de-sac*, led into from the south-west, by a moderately-open and not very long gully, called Cave Creek. The flat, having no outlet for its drainage waters, the latter disappear by percolation, and find their way into the cave; but in flood time the mode of escape of the water is only too apparent, by passing down the two lower entrances. Against and within the lowest of these are piled tons of dead timber, varying in size from mere sticks, up to large trunks and butts of trees, mixed with silt and general *débris*. To such an extent is this packed and wedged within the lowest entrance, that ingress is here impossible; but at the

second hole, a few yards higher up the face of the hill, an inward passage can be accomplished, after a little squeezing through the accumulated rubbish. We entered by this opening. The main entrance, however, is by the third aperture again a few yards higher up the hill, and this way is comparatively easy. The course of the drainage water of the Cave Creek flat, when once picked up within the cave, is traceable only for a comparatively short distance, when it disappears further underground, to reappear on the opposite side of the hill, and ultimately reach the Murrumbidgee River, its entire length, from entering on one side the hill to leaving it on the other, being, according to local current report, about half a mile. Portion 1, Parish of Narrangullen, is in the name of Alexander Raby Riley, but I was informed, is now the freehold of Dr. Campbell, of Yass.

III.—The Cave Chambers.

On entering by the middle of the three openings, a short drop of eight or ten feet is encountered, passing thence into a small chamber, narrowing at its further end, and then opening out into a large oval hall, partially illuminated by a stream of daylight, from the uppermost of the three entrances. On entering this chamber the sound of running water is heard, the creek having found its way through from the flat above. It flows along the bottom, or western side of the chamber, the remainder of the latter being taken up with a large talus proceeding from the daylight opening before referred to. At the further end of this hall, which, for the sake of distinction, may be called Chamber 2, the rivulet disappears under masses of fallen limestone, and stalagmite, and over this the explorer has to climb before reaching the inner portions of the cave. Chamber 2 is but little short of one hundred and twenty feet long, and too high for the faintest estimate approaching accuracy to be made. On crawling over the slippery surface of the the fallen blocks of limestone, at the inner end, under a low roof, the rivulet is again struck in Chamber 3, a huge, gloomy, black space, even larger than the preceding chamber, being at least two hundred and twenty-five feet in length. The creek winds its way along the bottom, disappearing at the further extremity, at the side of an immense irregular mound composed of limestone, stalagmite, and earth. On surmounting this obstacle, a passage is entered, more or less in red earth for some sixty feet, which has to be traversed on hands and knees. This leads to a crevice-like passage, opening into Chamber 4, a long irregularly-formed vacuity. On entering this chamber there is a rather fine, although not very large, stalagmo-stalactitic formation on the right-hand side, resembling an altar and canopy over it, the latter consisting of a series of organ-like flutings. A short distance beyond this a stalagmitic terrace crosses the chamber, marking off the larger half of the remaining portion as a shallow, miniature lake, about one chain in length. The roof of the chamber here descends and the walls come together, rendering the succeeding portion tunnel-like, the water again resuming its rivulet-like form where the chamber reopens, meandering between small sandy

and shingle banks, until lost on the lefthand side, apparently through a fissure in the floor, or just at the junction of the floor and roof, noiselessly, and without commotion. This is the last point where flowing water was observed by us.

At the end of this irregular chamber, attaining a length of at least three hundred and sixty feet, the floor is occupied by a series of very beautiful, miniature, brown stalagmitic terrace-pools, placed transversly across the chamber, each little pool somewhat semi-lunate in shape, and at a rather lower level than the one behind it. This line of terraced-pools is nearly one chain in length. The pools were filled with clear cold water. From the end of this terrace an upward passage leads to the fifth and last chamber. We say last, because we found no further ingress could be made, from fallen material, and general cave rubbish. A number of good stalactitic and stalalmitic formations are visible in this chamber.

In all, the Narrangullen Cave, so far as explored by us, is from the south entrance, about two hundred and sixty yards long.

IV.—General Remarks.

According to the statements of local residents the Narrangullen Cave enters both from the south and north sides of the hill it penetrates, the former being the intake, the latter the exit of the rivulet. It was the exit portion we were unable to visit, and have no idea, therefore, of the distance invisibly traversed by the water between the two portions. Assuming the entire course to be half-a-mile, as reported, we were surprised to find the traversable part of the cave comparatively so short.

The chambers are very dirty, arising no doubt, in the first instance from the amount of sediment brought in by the water; and secondly, from the existence of many hundreds of bats.

As rock excavations, the chambers are remarkably fine, very lofty, with irregular, and in some places jagged roofs, and rough rock-strewn floors.

The amount of cave-earth, as compared with that in the Goodravale Caves is inconsiderable, and we did not observe any traces of fossil bones.

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XV.—On the Occurrence of Leucite-Basalt at Lake Cudgellico. (Cargelligo): by G. A. Stonier, F.G.S., Geological Surveyor.

Leucite rocks, so far as has been yet observed, occur as outliers of lava, occupying limited areas, although widely separated from each other. In New South Wales they have been found only in the form of Leucite-Basalts, and have been recognised in the following localities:—

(1) Byrock Mt., near Bourke.
(2) El Capitan, near Cobar.
(3) Harden, south of Young.
(4) Lake Cudgellico, west of Forbes.

El Capitan is forty miles south from Byrock, and Lake Cudgellico one hundred and sixty miles south from El Capitan. Harden is one hundred and forty miles south-east from Lake Cudgellico, twenty miles south from the township of Young and one hundred and fifty miles from the coast.

The first recorded occurrence of leucite in Australia followed Professor David's examination of the artesian water area around Bourke in 1885.*

In 1887, the El Capitan rock was discovered conjointly by Mr. Geological Surveyor W. Anderson and the Rev. J. Milne Curran; in 1891, the latter gentleman noted the Harden rock, and in August 1892, the Author of this paper found Leucite-Basalt at Lake Cudgellico.

* Min. Mag., 1887, pp. 193-194.

The two former have been admirably described by Professor T. W. E. David, B.A., F.G.S., &c., and Mr. W. Anderson,* and also, in addition to the Harden rock, by Rev. J. Milne Curran.†

Lake Cudgellico is situated on the western boundary of the Central Division of the Colony, and within five miles of the Lachlan River. The surrounding country is mostly covered with Pleistocene red soil, but in the immediate vicinity of the lake the Silurian slates outcrop, and an intrusive (?) quartz and felspar porphyry forms a range of hills a little to the south-west of the township. The basalt runs in a thin tongue down to the lake, but the main mass is about a mile to the west. It presents the usual features characteristic of the Tertiary lavas, giving a rough stony outcrop, weathering into spheroidal boulders and yielding a scanty soil and vegetation. The flow does not cap the higher hills of quartz and felspar porphyry, but rests on the lower hills of Silurian slates. Its under surface is scoriaceous, and in one place has a brecciated or tuffaceous appearance. Prospecting operations have hitherto failed to reveal the existence of any contemporaneously formed alluvial deposits under this sheet, and its age, although in all probability Tertiary, is, therefore, at present undeterminable.

In hand specimens the rock is of a bluish black colour, compact, and fine-grained, but rendered distinctly porphyritic by small crystals of olivine, which can readily be detected without the aid of a pocket lens. Seen in thin sections the rock is micro-crystalline, and composed chiefly of leucite, olivine, magnetite, and augite, with a little microlitic base consisting of augite, magnetite, and leucite.

The leucite is micro-crystalline, and occurs as grains, aggregations, and amorphous masses. The first mentioned are, as a rule, irregularly shaped, and do not show, except in the case of a few small crystals, the typical polyhedral sections. Leucite is very plentiful and its inclusions are very numerous, and arranged in more or less perfect zones characteristic of the mineral. Its form of occurrence as amorphous masses is peculiar, as the latter have followed the contour of a typical crystal, and show its characteristic crystalline form more clearly than the mineral itself does. The inclusions consist chiefly of colourless glass, microliths of augite, opaque granules of magnetite, and a few rods of apatite (?) The leucite is not evenly distributed, but is frequently arranged in a circular form enclosing portions of the base as described from the Byrock slides. It would appear generally to have been the last mineral to crystallize, but in places to have intercrystallized with the magnetite and augite, and in one portion of the slide with mica also.

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* Records Geol. Survey N. S. Wales, I, Pt. 3, pp. 153-172.
† Proc. Linn. Soc. N.S. Wales, 1887, II (2), pp. 974-975, and Proc. R. Soc. N. S. Wales, 1891, XXV, pp. 210-211.

The olivine occurs as macroscopic grains, and is particularly fresh and free from decomposition; in this respect, as well as in the size of the grains, resembling the El Capitan rather than the Byrock specimens. Well-formed crystals are rare, and, although some of the edges are still fairly sharp, most of them are in various stages of corrosion, one grain in particular having unquestionably been reduced to a half of its former size. Only one crystal shows the ordinary six-sided section, and nearly all are traversed by irregular cracks chiefly transverse to the principal axis; along these cracks and the periphery of the crystal, the olivine has been altered to serpentine, in some cases with an aggregation of magnetite which has probably segregated from the olivine during its passage into serpentine. The mineral is colourless and shows several cleavage planes. The inclusions consist chiefly of magnetite as isolated crystals and aggregations.

The augite is found as microliths forming a large proportion of the base, and also in micro-crystalline, and occasionally micro-porphyritic prisms, generally elongated in the direction of the principal axis. They are coloured a light yellowish green, and show a tendency to assume a flow structure around the olivines. This structure, however, to judge from the broken appearance of one prism much elongated, may have been modified by a subsequent movement in the rock. Several of the crystals are multiple twinned, and might be mistaken for felspars, which latter do not appear to be present in the slide.

Magnetite occurs as small, isolated, and well-formed crystals, irregularly scattered through the base, and as aggregations near the edges of the olivines, which, in several places, are almost encircled by them. As inclusions in an augite prism, they are arranged parallel to the periphery of the crystal. Occasionally there is a tendency to assume the dendritic form, but the bulk of the magnetite occurs as isolated crystals.

Mica is of the rich brown variety, and occurs in long strips, most of which appears to be primary, with a little secondary mica close to the segregations of magnetite around the olivines. The primary mica shows a strong basal cleavage and encloses leucite and magnetite.

A comparison of the above description with those of the Byrock and El Capitan slides, shows that this Lake Cudgellico Leucite-Basalt resembles, in general microscopic characters, the latter rather than the former, and that it is differentiated from both chiefly by the greater size of its olivines and augites. A detailed description of the Harden rock has not been published.

Professor T. W. E. David has kindly confirmed the occurrence of leucite in the slides.

Since the above was written, the Author has examined, at several points, a basalt sheet at Bygalore, twenty-four miles east-south-east from Lake Cudgellico. The lava is found to be a Leucite-Basalt, resembling the Cudgellico rock in macroscopic characters; apparently it occupies an area of twenty square miles.

There has also been an opportunity of seeing the Harden rock *in situ*. One section proves to be of special interest, as it is the first instance in the Colony, and now recorded apparently for the first time, where a Leucite-Basalt is associated with an intrusive rock; the intruded rock is a coarsely-crystallized ternary granite.

XVI.—On the Occurrence of a Plant, allied to *Schizoneura*, in the Hawkesbury Sandstone: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plate XIII.]

Schizoneura, so far as known to the Writer, has never been recognised as an Australian Mesozoic plant, nor does the late Dr. Ottokar Feistmantel refer to it other than in a most emphatic manner, thus: "In Australia it does not occur."* *Schizoneura* is an exceedingly characteristic European Triassic plant, and more particularly of the Gondwana System in India.

Dr. Feistmantel has clearly shown the distinction between *Schizoneura*, *Zeugophyllites*, and *Noeggerathiopsis* (*Noeggerathia*, auctorum.)

In *Schizoneura* the leaves, really portions of the spathe, are numerous, long, linear, and biattenuate, opposite on the stalk, and consist of leaflets, united along their margins into one leaf. By this connection the spathe is formed, but "in the process of development, this sheath splits along the sutural lines either into the leaflets again, in various degrees of completeness, or, as it appears, much more frequently into two portions, generally equal in size, and spread out, so that they appear opposite."† These characters, remarks Feistmantel, distinguish *Schizoneurea* from *Noeggerathiopsis*.

In *Zeugophyllites* the "veins are much more numerous, and they belong to the *leaf itself*, which is not composed of several leaflets."‡. Very little seems to be

* Pal. and Mesozoic Plants E. Australia—*Mem. Geol. Survey N. S. Wales, Pal. Series, No. 3*, 1890, p. 77.
† Pal. Indica (Gondwana Flora), 1880, III, Pt. 2, p. 59.
‡ Records Geol. Survey India, 1877, X, Pt. 4, p. 200.

really known about this genus, and Feistmantel even suggests from Brongniart's original remarks, that the latter's *Zeugophyllites*, is, after all, but a *Schizoneura*,* and it seems very probable, therefore, that we have to deal with the former simply in its Australian aspect. In Australia we are acquainted with only one published species, *Z. elongatus*, Morris, an oblong-elongate leaf, truncate at the base, and with very numerous equal parallel veins, but of which the mode of attachment is even to this day unknown. Morris says,† "These leaves were probably sessile, or even amplexicaul, as might be inferred from their slightly thickened base, and pinnately arranged, at short distances, along a common stem, after the manner of the foliation of *Schizoneura*, Schimper." Morris' figure represents a leaf narrowed at the base, widest in the middle, and attenuated at the apex; in other words, generally lanceolate, as distinguished from the spathulate leaves of *Schizoneura*. Of *Zeugophyllites*, as I have before said, we know not the growth, but Feistmantel, shortly before his death, in his "Uhlonosné útvary v Tasmáni,"‡ referred the leaves to *Podozamites*. This may possibly turn out to be the case; but, so far as existing evidence goes, is purely an assumption. His figures are simply a reproduction of those given in Johnston's "Systematic Account of the Geology of Tasmania,"§ and, like Morris' original, are separate and unattached.

Morris described *Zeugophyllites* only from the Mesozoic beds of the Jerusalem Basin, Tasmania; M'Coy determined‖ what he believed to be the plant from the shales of Mulubimba, the Aboriginal name for Newcastle, and, therefore, from the Permo-Carboniferous Coal-measures. From this determination of *Z. elongatus*, its occurrence as a Coal-measure plant has crept into various lists and catalogues. As the distinction of the plants of our true Coal-measures from those of the overlying Mesozoic beds is a point of the highest practical importance, I have specially investigated the subject of these two plants, with the following result. The characters of the Tasmanian Mesozoic *Zeugophyllites elongatus* have already been pointed out. The Mulumbimba plant, on the contrary, from the specimens now before me, is widest for the entire apical third, thereby producing an elongately club-shaped leaf, very different in shape to its opponent from the higher series. The outcome, therefore, is, that the Newcastle supposed *Zeugophyllites* cannot be retained in that genus, and may, for the want of a better name, be known for the present as *Noeggerathiopsis elongata*, Dana, instead of *Noeggerathia*, the genus to which Dana transferred it;¶ the Tasmanian Mesozoic species remaining as *Zeugophyllites elongatus* Morris, notwithstanding Feistmantel's proposition to refer it to *Podozamites*, for which there is no published evidence at present.

* Pal. Indica (Gondwana Flora), 1880, III, Pt. 2, p. 61.
† Strzelecki's Phys. Descrip. N. S. Wales, &c., 1845, p. 250.
‡ Spisův Počtinych jubilejni cenou král ceski společnosti náuk v Praze. Cislo III, 1890, p. 103.
§ Pl. 22, f. 1 (4to., Launceston, 1888).
‖ Ann. Mag. Nat. Hist., 1847, XX, p. 152.
¶ Wilkes' U. S. Explor. Exped., Geol. X, 1849, p. 715.

The incongruity of uniting the two plants appears to have struck the late Rev. J. E. T. Woods, for he remarks:* "*Nœggerathiopsis elongata.*—This is a doubtful species which Dana identified with Morris' *Zeugophyllites elongatus*, but says that it was found at Newcastle, which is clearly an error."

Lastly, Mr. R. M. Johnston† considers *Z. elongatus*, Morris, to be a *Poacordaites*, and, therefore, a Conifer, basing his opinion on the supposed general resemblance of its leaves to those of the latter genus, and its constant occurence in company with quantities of coniferous wood in the Tasmanian Upper (or Mesozoic) Coal-measures. Possibly this may be the true explanation.

Mr. J. Evans, Manager of the Bulli Colliery, has recently presented numerous plant remains from the shale roof of the No. 1 Seam at that mine. Amongst these is the subject of Pl. XIII. In the Departmental Annual Report for 1891,‡ I returned this fossil, from imperfect knowledge, as *Zeugophyllites elongatus*, but on a more complete study I now see that it in no way differs from *Schizoneura*, except in one point. It displays six leaves, placed in pairs along a thin faintly striated stem, at regular distances apart, but I cannot detect any jointing of the stem, and so producing a division into nodes and internodes. The basal pair of leaves is the largest, the leaf on the left being the larger, and nearly perfect. It is four inches long, and half an inch wide, lanceolate in shape, truncate at the base and amplexicaul. The other leaves become smaller as the stem is ascended. The veins are simple, separate, sub-parallel in their middle course, and converging at the base and apex of the leaf, more so at the latter than the former.

Now, it will be observed that the mode of articulation is that of *Schizoneura*, the leaves, although not as broad and spathulate as some of those figured§ by Feistmantel in the Indian plant, are practically similar to many others.‖ On the other hand the leaves of our plant possess only five veins each at the utmost, which is less than in typical leaves of *Schizoneura*, wherein they are often as many as eleven,¶ but in some cases only six,** and even five.†† Feistmantel says‡‡ the "least number is five, six, seven on each portion . . . and, consequently, the portions (pseudo-leaves) are narrow." What is of more importance, however, is that neither of the leaves in the Hawkesbury plant shows any trace of splitting into pseudo-leaves. With the exception of this character, and the non-articulation of the stem—a feature on which I am inclined to lay very much less stress, as it may be purely accidental—our plant is to all intents and purposes a *Schizoneura*. That the

* Proc. Linn. Soc. N. S. Wales, 1883, VIII, p. 154.
† Proc. R. Soc. Tas. for 1886 [1887], p. 179.
‡ Ann. Report Dept. Mines and Agric. N.S.Wales for 1891 [1892], p. 269.
§ Pal. Indica (Gondwana Flora), 1880, III, pt. 2, t. 1 A., f. 2, t. 3 A., f. 1, t. 6 A., f. 1 and 3.
‖ *Ibid.*, t. 1 A., f. 4, t. 3 A., f. 2 particularly, and t. 10 A.
¶ *Ibid.*, t. 7 A., f. 1, t. 5 A., f. 4.
** *Ibid.*, t. 8 A., f. 1, t. 10 A., f. 5.
†† *Ibid.*, t. 10 A., f. 4.
‡‡ *Ibid.* p 62.

latter is not a *Zeugophyllites* appears pretty certain from its venation, and if Feistmantel is correct in referring *Z. elongatus* to *Podozamites*, the dissimilarity only becomes the stronger, for in this genus the leaflets are always alternate, here they are opposite.

To sum up, therefore, it may be stated that—(*a*). We have a plant from the shale roof of the Bulli Seam with leaves possessing the outline of those of *Schizoneura*; (*b*.) These leaves have the same arrangement on the stem, and method of articulation, but do not subdivide into pseudo-leaflets as in *Schizoneura*; (*c*) The venation approximates to that of *Schizoneura*, and not *Zeugophyllites*; (*d*) We have no direct evidence of the occurrence of the last-named genus in Australia.

Under these circumstances I shall provisionally content myself by placing this on record as *Schizoneura? australis*.

XVII.—Notes on the Rosebrook Caves, near Cooma: by W. S. LEIGH, Inspector of Caves.

[Plate XIV.]

THE limestone at Rosebrook, situated about nine miles north-east of Cooma, in the Parish of Woolumla, County of Beresford, in which a number of caves or large pot-holes have recently been discovered, has an area of about four square miles.

The northern portion, which is included in Reserve No. 1034, is about two thousand six hundred feet above sea-level. From this point, running generally south-east, over a gradually falling and undulating plain, it can be noticed cropping up at intervals for a distance of four or five miles. A continuation of this line would strike the Umaralla River at ten miles, and eight miles beyond this the Kybean Limestone, explored by Mr. R. Etheridge, junr., Palæontologist, and the Writer,* which would appear to be an extension of that under notice, the texture and colour of each being alike. Also, like the Kybean Limestone, it can hardly be called fossiliferous, as only a few scattered coral specimens were met with.

On or about the reserve, where the out-crop is most marked, the surface of the limestone is traversed by numerous joints and lines of fracture, intersecting each other at different angles, which presents a face of knife-eged ridges rising almost vertical.

* Records Geol. Survey N. S. Wales, 1892, III, Pt. 1, p. 21.

Towards the southern or lower end of the belt the limestone is covered at intervals with thick patches of alluvium, and where exposed the rock appears more solid and compact than on the higher ground, fewer crevices being noticed. At the northern end these natural openings and shafts in the limestone are numerous. Within a radius of four hundred yards about twelve of the most promising looking holes were enlarged and explored, and, although most of them were found to connect with more spacious cavities below, in only one instance, if viewed from a spectacular stand-point, did the search prove successful.

A descent into the opening referred to, which is situated on Portion No. 125, south of and adjoining the reserve, was effected after the removal of two slabs of limestone, which, having become wedged together near the surface, effectually covered the funnel-like shaft below. The total depth of the shaft, to floor of the main cave, is eighty feet. At twenty feet below the surface it is about two feet six inches in diameter, which varies very little for a further distance of thirty feet, at which depth a landing is effected on a narrow ledge of rock spanning an immense cavity, the main chamber of the cave, the floor of which is reached after a further descent of thirty-two feet. This chamber is about forty feet long by twenty feet wide, and averages thirty feet in height. The floor immediately below the entrance shaft is strewn with limestone *débris*, the sombre appearance of which is in marked contrast with the surrounding white stalagmitic bed. From the roof and rugged projections on the walls depend long tapering stalactites and "shawls," relieved at intervals with patches of crystallised and ripple-marked rock. Branching from the northern end of this chamber, running generally north-west, is a narrow circuitous passage about fifty feet in length, the whole surface of which, floor, roof, and side walls, is coated with glistening white calcareous growths. On emerging from the passage, the terminal chamber of the cave in the form of a pretty grotto, about twenty feet long by eight feet wide, is entered, which, by reason of its delicate coral-like stalagmitic floor, might appropriately be termed the "Coral Grotto."

The cave on the whole, though not large, is strikingly pretty and interesting, and the discovery naturally led to the belief that some of the many similar crevices, noticed in close proximity, would, on examination, be found to lead to cavities equally interesting and important. In almost every instance, however, after the entrance had been enlarged for a certain distance, only vertical shafts or "pipes" ranging in depths from twelve to one hundred and fifteen feet, were found. One of these shafts was opened out to a depth of seventy feet and bottomed on solid rock, the size of the natural opening varying very little the whole distance.

This, of course, proved an unsuccessful undertaking, but the next crevice tried, gave better results. At ten feet below the surface the natural shaft was found to break abruptly into a spacious cavity, the width increasing as one descends, until

at sixty-five feet deep, becoming circular, it is about twenty feet in diameter. At this point a narrow ridge of rock, running across the centre of the shaft, divides the cave into two branches, each of which being on a steep gradient, forms an obtuse angle with the main trunk shaft, and can be descended a further distance of fifty feet. With the exception of one or two small fissures, evidently old watercourses, no passages lead off from the bottoms of the shafts. A few isolated stalactites and "coral" patches, of a brownish tint, comprise the drip-stone specimens of the cave.

The other openings explored are simply vertical shafts of various depths ranging from two to three feet in diameter, and contain nothing of interest. In fact, the cave first noticed, so far as recent explorations have revealed, is the only one of the series, in the inspection of which one would feel somewhat recompensed for the amount of exertion required, and trouble experienced in descending and traversing it.

As before inferred, the northern portion of the Rosebrook Limestone appears to be thickly perforated with cavernous orifices or "pot-holes," and the fact of the lower floors of those inspected being covered with a plastic sediment of drift and waterworn boulders, exhibits abundant evidence of the passage of bodies of water through them, which settles temporarily on the lower levels, eventually escaping by percolation through small orifices and joints, into the lower limestone.

Some of the rock crevices were found to be filled, and the natural shafts partly choked with a deposit of red earth, which, on examination, proved somewhat ossiferous, a collection of bones being obtained from the deposit. They include portion of the remains of a Wombat (*Phascolomys*), a Wallaby, and a Native-cat (*Dasyurus*), in all probability of existing species. As no specimens of an extinct animal, such as found in the Wellington Caves, were obtained, the same remarks, as applied by Mr. Etheridge, referring to the bone deposits, in his notes on the Kybean Caves,* would apply in this instance. "It may be concluded that the accumulations in the Kybean Caves belong to the latter period of cave deposits, and not to the more ancient, such as those of the Wellington Caves."

It might be mentioned that in close proximity to the Caves was found in a horizontal crevice, formed by an overhanging rock, the more or less complete parts of a human skeleton, probably that of an Aboriginal. The remains, which were covered by a thin layer of soil, were too much decayed and friable for preservation, the skull even being in a number of pieces. Considering the small size of the cavity and the position in which the skeleton lay, it is evident that the body at burial had been tightly wedged between the lower limestone bed and the upper sheltering rock, thus following the universal practice of the aboriginals of disposing of their dead in the smallest possible space.

* Records Geol. Survey N. S. Wales, 1892, III, Pt. 1, p. 24.

XVIII.—Idiographic Carvings of the Aborigines at Point Piper, Rose Bay, Port Jackson, and at Hawkesbury: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

[Plate XV.]

I.—Point Piper.

POINT Piper, forming the western promontory of Rose Bay, Port Jackson, is a low headland of Hawkesbury Sandstone, not more than thirty feet above high-water mark. The sandstone is broken up into several large rounded tables, separated by large joint-fissures, and on these the carvings are delineated. Point Piper forms part of the estate of Lady Martin, who was kind enough to allow Mr. G. H. Barrow and the Writer to make the requisite examination of the locality.

The first object to attract attention is the large fish (Pl. XV, Fig. 1.), twenty-two feet long, by twelve and a half wide, and within its outline are other subordinate carvings. This fish is remarkable for the roundness of its anterior outline, great bulk, and small well separated tail-flipper. It is different in type to any yet visited and recorded by us, and is second only in size to two of the immense fish visible at Flat Rocks, near Manly. It is divided at about one-third from the tail by an incised line.

Within the outline of the fish are four subordinate smaller fish (Pl. XV, Figs. 2-5.), each after a type of its own, and no two alike. Those at the anterior end of the larger fish appear to be grouped round a circle (Pl. XV, Fig 6.), whatever this latter may be intended for; but supposing the contiguous outline to represent the dorsal rather than the ventral line, it would not be too much out of position to represent the eye. At the posterior end is a shield (Pl. XV, Fig. 7.), with its longer axis parallel to that of the fish, with the usual transverse bars, and diamond shaped apices. It is four and a half feet long.

On another section of the sandstone table is a grand Kangaroo (Pl. XV, Fig. 8.), a trifle over ten feet high, etched in a north and south direction, and facing the east. The fore legs are delineated, with the hands distinctly carved, and one of the hind legs represented. The tail is also in full proportion, and the eye not forgotten. This is one of the best examples of a Kangaroo we have yet met with, in some respects even better than those above Bantry Bay, Middle Harbour. Contiguous, but further south, is the head alone of another

Kangaroo, excellently outlined (Pl. XV, Fig. 9.), and a nondescript fish (Pl. XV, Fig. 10.), seven feet long, without any particular character except its homocercal tail.

A third section of the rocky surface carries the rude figure of a man, with a squarish head (Pl. XV, Fig. 11.), and what is of rare occurrence, eyes depicted. The figure is five feet high, and has the knees and elbows typically angulated after the usual aboriginal manner.

II.—Hawkesbury.

This group of Idiographic Carvings is situated in a depression between two hills, on the Old Peat's Ferry Road, about three miles from Hawkesbury (Peat's Ferry), and five from Berowra Station. The road for some distance follows the crest of the divide between Cowan and Berowra Creeks. It passes directly over the large Hawkesbury Sandstone table on which the figures are delineated, but I regret to say, also, in a great measure obliterated. In pre-settlement days this must have been a most secluded locality, and well adapted to the sacred rites carried out at such spots. Several important and interesting facts are to be gleaned from this group of carvings, although it was found impossible to do more than copy the better preserved ones.

The following are the principal figures:—A fish (Pl. XV, Fig. 12.), twelve feet seven inches long, with one eye and the mouth shown, the latter open. The tail is square-ended, and there is a dorsal fin, curved in the opposite direction to that seen in nature. Immediately succeeding the fish is the usual male figure, the head towards the fish, and the arms extended above the head. The left leg is provided with a foot, the right without, or it has been obliterated by age (Pl. XV, Fig. 13.) Extending at right angles to the fish, and in a line with the male outline, and leg on to it, are a series of diminutive male figures, probably those of boys, and of which two are shown (Pl. XV, Fig. 14.) The line of boys extends for forty-five feet, and at its termination is the outline of a Kangaroo (Pl. XV, Fig. 15.), with the curvature of its back rather imperfect, co-mingled with a number of other indistinct figures. To the right of this is the figure of another Kangaroo with a badly executed head, and a very short fore limb (Pl. XV, Fig. 16.) Contiguous to the larger Kangaroo, at the end of the procession of boys is another man delineated (Pl. XV, Fig. 17), with the head sunk on the shoulders as it were, provided with a belt, and peculiar in having the penis represented by a single incised line, instead of the manner usual in these representations. The last object decipherable, for there are numbers of which nothing can be made from their weathered condition, seems to be meant for a canoe (Pl. XV, Fig. 18), with four divisions or stretchers.

III.—The Meaning of the Carvings.

So far as my memory serves me at present, no explanation of these Idiographic Carvings has been offered, at any rate, no detailed explanation, beyond that afforded by Dr. A. Carroll,* and a few remarks by myself.† Dr. Carroll regards them apparently both as totemic and symbolical. He says, "The various birds and fishes were the totemic or tribal emblems of other tribes";‡ and again—"the carvings and engravings of the original inhabitants of Australia are symbolical of their tribal myths and laws."§

The frequent occurrence of these carvings throughout the mid-eastern district forbids one ascribing the nature of Initiation, or Bora grounds, to all of them, a point on which I am quite in accord with Dr. Carroll;‖ no doubt the larger and more inaccessible ones were so, but to imagine solitary figures, or groups of two or three to be of this nature, is to recognise the almost indiscriminate consummation of those rites held most sacred by the Aborigines.

These minor groups Dr. Carroll looks upon as the records of "raids of tribe upon tribe, the conquest of districts by invading tribes . . . . the boundaries of hunting-grounds and tribal territories." On these points I am not at present in a position to express an opinion.

It is now known that the Aborigines, especially of the south-eastern portion of the Continent, depicted their Bora grounds, or Baiamai's ground, the ground of the "Great Creator"—that is to say those spots where initiatory religious ceremonies connected with the transfer of a male from the condition of adolesence to that of full manhood took place—with figures carved in the turf or soil, or on the butts of trees. Such grounds according to Dr. John Fraser were permanent. A spot of this nature is described near Wellington by Mr. J. Henderson,¶ who remarks—"A long straight avenue of trees, extended for about a mile, and these were carved on each side, with various devices, most of which were apparently intended to represent serpents, in all their different attitudes. On one extremity of this, the earth had been heaped up, so as to resemble the gigantic figure of a human being extended on his breast . . . . a narrow pathway turned off towards the left, and soon terminated in a circle, which was enclosed by a wall, composed merely of loose earth."

Another is described by Dr. Fraser,** who informs us that the presiding elders formed and cleared two circular enclosures, a larger and "a smaller," about a quarter of a mile from each other with a straight track connecting them; the trees that

* Centennial Mag., 1888, I, Nos. 1 & 2, p.p. 53 & 89.
† Records Geol. Survey N.S. Wales, 1890, II, Pt. 1., p. 34.
‡ *Loc. cit.*, No. 1, p. 54.
§ *Loc. cit.*, No. 2, p. 89.
‖ *Loc. cit.*, No. 2, p. 90.
¶ Obs. Colonies N. S. Wales & V. D. Land, 1832, p. 145.
** Journ. R. Soc. N. S. Wales for 1882, XVI, p. 205.

grow around the smaller circle they carve at about the height of a man, often much higher, with curious emblematical devices and figures." The young initiate or *Boombat** was made to lie down in the centre of the larger circle, and, after other preparatory ceremonies, was led down between the avenues of carved trees to the smaller enclosure. Fraser adds that the Yùin tribe, a section of the Murring people, who extended from the Shoalhaven River to Cape Howe, placed along the path figures, moulded in earth, of various animals, and one of *Daramūlŭn*, "a spirit god," whom they feared.† The *Boombat*, who had been placed in the smaller circle was led to each of these objects, carved trees, or images, and allowed to look at them, when their significance was explained to him. *Daramūlŭn* was supposed to preside at the Bora as "Lord of the Mysteries," although in some tribes he was the second deity only, "not the supreme master, but the son of *Baiamai*, who ruled everything." Touching *Daramūlŭn*, Dr. Fraser says‡ that in the work of creation *Baiamai* was assisted by a *demiourgos* named *Daramūlŭn*, "and certain birds and animals are also associated with him as agents." On the other hand, quoting Howitt,§ he was the supreme spirit believed in from the "sea coast across to . . . about Yass and Gundagai, and from Omeo to at least as far as the Shoalhaven River, in a line approximately east and west."

Ceremonies of initiation, differing but little in detail, were practised by five large tribes in the south-east, notwithstanding a diversity of class systems, viz.:—The Wolgal, Ngarego, Theodora, Coast Murring, and Wirādjuri, forming more or less one nation or community, and occupying a very large area of New South Wales "from Twofold Bay to Sydney, and (including the Lachlan River) as far west at least as Hay."‖ In this community the ceremony is called *Būnan* or *Kūringal*, and again includes two circles, as at Wellington,—the great *Būnan* with a clear path leading to the small *Būnan* enclosed by boughs, with some of the trees around bearing figures or marks.¶ The initiates in this instance are shown the figure of *Daramūlŭn*, and instructed concerning him. At the conclusion of the various impressive ceremonies the procession of neophytes and old men on its way to the camp is halted, and the latter "having carefully cleared a piece of ground, proceed to mould in earth, in high relief, the life-sized figure of a naked man in the attitude of the dance . . . This is *Daramūlŭn*. The novices are brought and placed in front of this figure and the dance then takes place."**

The various objects exhibited are those instituted for the good of man by *Daramūlŭn*. Such a belief seems to have existed amongst the Kurnai of Gippsland, and probably other tribes likewise, for Howitt, speaking of the Kurnai, says,

* The name of the initiate varies in different tribes.
† Journ. R. Soc. N. S. Wales for 1882, XVI, p. 206.
‡ Journ. R. Soc. N. S. Wales for 1891, XXV, p. 262.
§ Journ. Anthrop. Inst. Gt. Brit. & Ireland, 1884, XIII, p. 193.
‖ Journ. Anthrop. Inst. Gt. Brit. & Ireland, 1884, XIII, p. 433.
¶ Journ. Anthrop. Inst. Gt. Brit. & Ireland, 1884, XIII, p. 440.
** Journ. Anthrop. Inst. Gt. Brit. & Ireland, 1884, XIII, p. 448.

"Long ago there was a great Being called *Mūngan-ngaur* [*Baiamai*], who lived on the earth, and who taught the Kurnai of that time to make implements, nets, canoes, weapons—in fact all the arts they know."*

Now, in endeavouring to apply the explanation afforded by these facts to the major groups of carvings, we are met at the outset by the absence of any remains of circles, or of pathways or objects connecting groups together. If such ever existed they have long disappeared. On the other hand, the objects portrayed bear such a close resemblance to those described by Messrs. Howitt and Fraser, respectively, and believed by the Blacks to have been instituted by *Daramūlŭn* for their good, that the conviction is forced on us that these large tabular masses of Hawkesbury Sandstone must have been selected as the sites of the *Bora* ceremonies of the local tribes. In the first place the figure of a man, or those of men, invariably present themselves at all the larger groups, and the absence of these figures at the smaller collections of figures is very marked. It is not invariably so, as Mr. J. F. Mann has figured† the outline of a man inside that of a fish at Berry's Head, one of the minor groups I visited some months ago in company with Mr. E. F. Pittman. These men outlines are portrayed with the arms and legs extended, always one or the other, usually both, and seem intended to represent a prone individual. We have seen that during the *Kuringal* of the associated Murring tribes the initiates were shown the figure of *Daramūlŭn*, and at the conclusion the old men moulded the figure of the god. The Page and Isis River Blacks, at the head of the Hunter River, made a rude figure of a man, from four to seven feet high, twenty-two feet long, and twelve feet wide, by laying down sticks and covering them with earth.‡ This figure was in the extended prone position. I think, therefore, that the idiographic male figure is intended to represent *Daramūlŭn*, or, when there are two this spirit and his paternal associate *Baiamai*.

The row of smaller male outlines (Pl. XV, Fig. 14.), are probably symbolical of the *Boombats*, who, as described by Fraser and Howitt, are made to lie down during certain portions of the south-eastern initiation ceremony. Such was also the case in the Wailwun Tribe, Barwon River;§ and amongst the Page and Isis River Blacks,‖ and other tribes. This line formation seems to have been a favourite one during these mysteries, for in one of the few pictorial representations of the *Bora* extant, contained in Lieut.-Col. Collins' work, "An Account of the English Colony in New South Wales,"¶ the initiates are represented seated in a line watching the elders performing the *Yoo-long Erah-ba-diang*.

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* Journ. Anthrop. Inst. Gt. Brit. & Ireland, 1885, XIV, p. 313.
† Proc. Geogr. Soc. Australasia (N. S. Wales and Vict. Branches), 1885, I, 5th plate.
‡ Macdonald, Journ. Anthrop. Inst. Gt. Brit. & Ireland, 1878, VII, p. 255.
§ Howery, *Ibid.* p. 254.
‖ Macdonald, *Loc. cit.*
¶ 2 Vols., 4to, London, 1798-1802 (Pl. 8).

We have seen how often shields are depicted in these groups. According to Dr. Carroll* the crossed shield was the emblem of a god, and also of fire; but in the Yūin Tribe, after the extraction of the tooth, an ancient, and probably sacred shield, handed down from past ages in the tribe, was sent round† accompanying the extracted tooth, to the various other tribes, with whom the operating tribe were in close connection.

Of the numberless other objects depicted amongst these carvings, some explanation may be given on a future occasion; in the mean time those interested will find the interpretation placed on them by Dr. A. Carroll in his paper‡ previously referred to. How intimately these figures are connected with that of the man, the following passage by Mr. Howitt will show, when speaking§ of the "exhibition to the novice of the representation of Daramulun, moulded life size in the ground, with examples dispersed round his figure, of all the weapons and implements invented by him for man's use."

In the Kurnai ceremony called the *Jeraeil*, after the initiates, or *Tutnurring*, are awakened from their last boyish sleep, and pronounced men, they are invested with the belt, and other articles of dress appertaining to manhood.‖ It is more than probable that it was to impress this on the mind of the initiate, that the figure represented in Pl. 15, Fig. 17., was provided with the belt.

Amongst the carvings figured from the Bantry Bay group, is that of a large tomahawk.¶ This is probably intended as the figure of *Daramūlūn's* tomahawk, "which he threw after the Emu, as he was descending by the path from the sky to the earth".**

According to a Kurnai legend, many of their ancestors, who survived a great flood, sent as a punishment, were turned into animals, birds, reptiles, and fishes, whilst *Tundun* and his wife became porpoises. The Coast Murring also had a legend how an eminent man of former times became a porpoise.†† Possibly some such belief may have extended as far north as our carving grounds, and a knowledge of it kept green by means of these sculptures.

* Centennial Mag., 1888, I, No. 1, p. 55.
† Fraser, Journ. R. Soc. N. S. Wales for 1882, XVI., p. 209.
‡ Centennial Mag., 1888, I., No. 1, p. 55.
§ Proc. Austr. Assoc. Adv. Sci. for 1891 [1892], III, p. 349.
‖ Journ. Anthrop. Inst. Gt. Brit. & Ireland, 1885, XIV., p. 311.
¶ Records Geol. Survey N. S. Wales, 1890, II, Pt. 1, t 2, f. 20.
** Journ. Anthrop. Inst. Gt. Brit. and Ireland, 1884, XIII, p. 452.
†† Journ. Anthrop. Inst. Gt. Brit. & Ireland, 1885, XIV, p. 314.

XIX.—The Australian Geological Record for the Year 1891; by R. ETHERIDGE, Junr., Palæontologist and Librarian, and W. S. DUN, Assistant Palæontologist and Librarian.

I.—Introduction.

IT is the intention of the Compilers, supported by Official recognition, to prepare annually for the "Records of the Geological Survey of New South Wales," a GEOLOGICAL RECORD of all Works, Reports, Papers, and Maps, coming under their notice bearing on the Geology, Mineralogy, Petrology, Palæontology, Applied Biology, Mining, and Metallurgy of the Australian Continent, Tasmania, and New Guinea, that have been published during the preceding year, with the view of affording assistance to the Reader in overcoming the Australian portion of the terrible mass of literature now flooding Geological Science, using this term in its broadest significance. With this view they cordially ask the co-operation of their fellow-workers in the other Australian Colonies and Foreign Countries, by sending their writings to the Library of the Geological Survey of New South Wales, at the Department of Mines and Agriculture, in Sydney.

The idea was conceived too late to publish the Record for 1891 in 1892, but a strong effort will be made in future to issue that for each respective year, as early in the succeeding twelve months as the publication of the various "Annual Reports" of the Colonial Mining Departments will allow, these containing by far the largest amount of local geological information. In doing this we depart, to some extent, from our recognized plan, in so far that the contents of the Annual Reports are noticed in the actual year of publication, instead of deferring it for twelve months, as it otherwise would be were the conception strictly adhered to. Thus, the Annual Report for 1891 is *published* in 1892, and in the ordinary way would be *recorded* in the Record for 1892, published in 1893; but in the case of this particular and like publications, and for the reasons stated, we prefer to anticipate matters.

The Record is published simply as a *Title-catalogue*, the duties of the Compilers in no way allowing more than this to be accomplished. The arrangement is under Author's names, or, when these are wanting, the leading word of the title; this is followed by the actual title, and then the abbreviated reference. Manuals in the general sense of the term, unless strictly Australian, will not be noticed.

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2. Etheridge (R., Jun.) On the Occurrence of an *Orthis* allied to *O. Actoniæ*, J. de C. Sby., and *O. flabellulum*, J. de C. Sby., in the Lower Silurian Rocks of Central Australia, p. 13, pl. 2.

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III.—Geognosy, pp. 6–12.
IV.—Geology, pp. 12–17.
V.—Mineral Resources, pp. 17–35.
VI. Appendices, pp. 35–53, containing :—
A. Report on the Collie River Coal, pp. 38–41.
B. Report on the Green Bushes Tin-field, pp. 41–47.
C. Report on the Darling Range, p.p. 47–48.
D. Report on the Country passed over between Albany and Perth, including the Stirling Range, Jerramungup, the Gordon and Pallinup Rivers, pp. 48–53.

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II. Wardens' Reports for the Year 1891, pp. 26–80.

III. Mineral Commissioners' Reports, pp. 81–91.

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V. Shakespeare, J. Annual Report of Northern Inspector of Mines for the Year 1891, pp. 108–117.

VI. Bennett, I. Annual Report of the Inspector of Mines of Central Districts, pp. 118–123.

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VIII. Thompson, W. Report of the Mineralogical Lecturer for the Year 1891, pp. 133–139.

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VI. MONTGOMERY, A. Notes on the Molesworth Calcining Process, pp. 12–13.

VII. MONTGOMERY, A. Report on the Macarthur-Forrest Cyanide Process for the Lixiviation of Gold and Silver Ores, pp. 13–14.

VIII. BELSTEAD, F.; SIMPSON, T.; MONTGOMERY, A.; HAWKES, S.; O'REILLY, C. Report of the Water-race Board to 30th June, 1891, pp. 14–15.

IX. MONTGOMERY, A. Report on the Proposal to Bore for Coal in the Township of Triabunna, Spring Bay, and its Neighbourhood, pp. 15–18.

X. MONTGOMERY, A. Addendum to Report on Coal found in the Neighbourhood of Spring Bay, pp. 18–19, with section.

XI. DIAMOND DRILL. Report of Strata passed through in boring for Coal in the Neighbourhood of Spring Bay, pp. 19–22.

XII. MONTGOMERY, A. Report on the Hydraulic Limestones of Maria Island, pp. 22–25, with map and section.

XIII. MONTGOMERY, A. Report on the Progress of the Mount Zeehan and Mount Dundas Silver-Lead Fields, pp. 26–43, with maps.

XIV. MONTGOMERY, A. Report on the Geological Structure of the Beaconsfield Goldfield, pp. 43–55, with maps, sections, and appendices.

XV. MONTGOMERY, A. Report on the General Geological Structure and Tin-bearing Gravels of the Gladstone District, pp. 57–72, with sections.

XVI. MONTGOMERY, A. Hydraulic Elevators, pp. 72–75, with plans.

XVII. DIAMOND DRILLS. Statement of work done, pp. 76–79.

XVIII. STATEMENTS. Pp. 79–82. [Gold won during years 1880–91; Quantity of Gold obtained during years 1880–91; Tin exported from Tasmania during years 1880–91; Coal raised during years 1880–91; Number of Miners, 1880–91; Number and Area of Leases held under "The Mineral Lands Act" and "The Gold-fields Regulation Act"; Number and Area of Leases in force, &c., 1890–91; Net Revenue from Mines; Dividends paid by Gold-mining Companies; Dividend Tax paid by Tin-mining Companies; Dividend Tax paid by Silver-Lead Mining Companies.]

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IV. MCCOY, F. Report on Palæontology of the Geological Survey for the Year 1891, p. 30.

V. TRAVIS, J. Officer in Charge of Statistical and Prospecting Branch. Report on the Expenditure of the Prospecting Vote, pp. 31–32.

VI. DUNN, E. J. Report on the Work done by the Underground Survey Party at Bendigo, during 1891, pp. 32–33.

VII. MINING INSPECTORS' GENERAL REPORTS, pp. 33–37.

VIII. MEEKISON, E. R., Inspector of Mining Machinery. Report on Mining Machinery, pp. 37–70, plans and sections. [Mining Boilers; "Garnier" Ore Concentrator; Mudie's Gold-saving Machine; Shedlock's Treatment of Refractory Ores; Lay's Vibrating Quicksilver Cradle; Tullock Concentrator; Arnold's Amalgamator; New Gold-saving Apparatus; Miller's Ore Washer; Carr's Disintegrator; Gates' Ore Breaker; Marsden's Crusher: "Steel Grinding Mill"; Dredge for Gold-bearing Rivers; Delbridge's Air-compressor; Joy's Valve Gear; Arthur's Patent Improved Method of Bushing the Cylinder of an Engine; Arthur's Patent Improved Counterbalance; Machinery at Berry Consols Extended Co.; Compressing Brown Coal into Briquettes; Gillott & Copley's Rotary Coal-cutting Machine; Brain's Electric Coal-cutter; Boyle's Gravity Hoisting Apparatus; Sleeman's Winding Indicator; Electric Hoist; Appliances used in Boring at North Magdala Company's Shaft, Stawell; Seale's Patent Water-purifier; Sleeman's Water-heater; Settle's Patent Water-cartridge; Francis' Patent Tamping Plug; Ventilating Fans; Indestructible Faucet; Strobach's Wire-rope Holder; Ratchet Screw-driver; Ramsay's Patent Levelling Staff; Underground Dams; Wells and Shafts; Miners' Thrift and Employers' Liabilities; Accidents in Mines; Tests of Victorian Timbers.]

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IX. FULTON, R.; NAYLOR, J.; COATS, J.; BARNES, B. Report of the Board of Examiners for Engine-drivers, p. 71.

X. PATENTS (MINING). Lists of Patents (Mining) granted in Victoria during the Year 1891, pp. 71–72.

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I. HOWITT, A. W., Secretary for Mines. Summary, pp. 5–14.

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III. BROWN, E. T. Notes on Survey of Extension of New Chum Line of Reef, Sandhurst, pp. 17–18, with map.

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VI. DUNN, E. J. Notes on the Geology of Moorabool West Parish, pp. 21–22.

VII. DUNN, E. J. Notes on Peterson's Reef, Gordon, p. 22, with plan.

VIII. STIRLING, J. Report on Examination of Coal Seams, South Warragul District, pp. 22–23, with map and sections.

IX. DUNN, E. J. Report on Site at which Coal is being prospected for, Parish of Metcalfe, pp. 23–24.

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XI. SILURIAN ROCKS. Notes in reference to Views showing Occurrences of Silurian Rocks, p. 27, with plates.

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III. DUNN, E. J. Report on the Parish of Fumina, Gippsland, pp. 18–20, with sections.

IV. DUNN, E. J. Notes on Mount Doran and Neighbourhood, pp. 20–22 with sections.

V. STIRLING, J. Report on Gold Discoveries, Crichton's Creek, Gembrook, pp. 22–24.

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II. ALLAN R. Report on Clune's Gold-field, p. 19, with plan and sections.

III. ALLAN, R. Report on the Jubilee Company's Mine, near Scarsdale, p. 19, with plan.

IV. MURRAY, R. A. F. Report on the Discovery of Stream Tin Ore, near the Buneep River, p. 20.

V. STIRLING, J. Notes on Character of Country between Leongatha and North Mirboo and between North and South Mirboo, pp. 20–21, with section.

VI. STIRLING, J. Preliminary Report on recently Discovered Coal-seam near Kilcunda, p. 22, with section.

VII. FORD, H. W. Notes on Boring for Water near Donnybrook, p. 22, with plan.

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II. Wardens' and Mining Registrars' Reports, pp. 67–142.

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V. MACKENZIE, J. Report of the Examiner of Coal-fields for the Colony of New South Wales for the Year 1891, pp. 187–196, with map and section.

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VII. ROWAN, J. The Half-yearly Report of the Inspectors of Collieries on the state of the Collieries in the Southern and Western Districts of the Colony of New South Wales, and Accidents for the Half-year ending 31st December, 1891, pp. 205–207.

VII. PITTMAN, E. F. Geological Survey of New South Wales. Report of Progress for 1891, by the Government Geologist, p. 207, with following Appendices.—

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3. ANDERSON, W. Progress Report by Mr. William Anderson, Geological Surveyor, pp. 248–249.

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3D. ANDERSON, W. Report on Water Supply for Broken Hill, pp. 254–259, with map.

4D. ANDERSON, W. Report on Wallah Wallah, pp. 259–260.

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6B. HAMMOND, P. T. [Report on Forest Reserve, No. 50 a, Parish of Belford, County Northumberland], pp. 264–267, with map and section.

7. ETHERIDGE, R., JUN. Progress Report of the Palæontologist for 1891, pp. 267–268.

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VIII. BOULTBEE, J. W. Water Conservation. Report upon the Public Watering-places of the Colony by the Officer-in-Charge, pp. 284–306.

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OBITUARY NOTICE. Charles Smith Wilkinson, F.G.S., F.L.S., V.P.L.S., New South Wales. Born 1843, died 23rd August, 1891. *Geol. Mag.*, 1891, VIII (3), pp. 571–573.

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PLATE XIII.

Schizoneura? australis, *Eth. fil.*

Remains of a plant showing three undivided leaves on each side of the stem.

Drawn from nature by Mr. G. H. Barrow, Australian Museum.

JAN 20 1894

DEPARTMENT OF MINES AND AGRICULTURE, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. III.] 1893. [Part 4.

XX.—On a Sand from Bingara: by GEORGE W. CARD, A.R.S.M., &c., Curator and Mineralogist.

THE following notes relate to a sand submitted for examination to the Geological Survey Branch. The grains of which the sand is composed are small, varying in size from a lentil downwards, and mostly angular. The larger proportion is very fine, thus rendering examination difficult. Owing to the predominance of a red constituent the prevailing colour is red, this being varied by the presence, in considerable quantity, of a mineral that appears black when coarse, and bright green when in thin flakes. When examined closely a large proportion of the smaller grains are seen to consist of transparent green fragments of this mineral. The constituent minerals will be briefly described.

1. *Garnet.*—This mineral constitutes the greater part of the sand. It occurs, chiefly, in grains of a dark red colour, of irregular shape, and varying in size from that of a very small pea down to the finest sand. One large piece occurred, measuring nearly two c.m. in longest diameter. The true nature of this piece was not evident at first sight, owing to a coating of clayey matter, but when broken it was found to consist entirely of granular red garnet. It would therefore seem as if the grains of this mineral had been derived from a rock in which it was an important constituent, if not a true "garnet rock." In only one case were crystal faces noticed, the faces of the rhombic-dodecahedron being just recognisable. One

or two of the grains were pitted and roughened, a few well rounded, while by far the greater number were irregular in shape with sharp edges and a conchoidal fracture :—

Colour :—Varies from deep red—almost black—to various shades of pink and red-brown.

Lustre :—Good, except in the case of the roughened grains, the well rounded particles approaching zircon in this respect.

Streak :—Almost or quite colourless.

Hardness :—Between 7 and 8—considerably below topaz.

Tenacity :—Brittle, thin splinters being readily obtainable.

Fusibility :—Very readily fused to a black globule, magnetic when crushed.

Specific-Gravity :—Satisfactory specific-gravity results were very difficult to obtain, owing to the small size of the particles. Using the Joly Balance, and weighing a number of grains together, the average result of a number of experiments was 3·88.

Blow-pipe Reactions :—Soluble in borax with iron reactions.

Almandine would appear to be the principal, or only variety present.

2. *Spinelle.*—When commencing the examination of the material, several grains resembling garnet were obtained which appeared to be infusible, and were therefore regarded as spinelle. No such grains having been found in a further supply of the sand, although a largo number have been tested, the occurence of this mineral must be considered doubtful.

3. *Mineral allied to Pyroxene.*—Next in abundance to garnet is a mineral opaque and black when of any thickness, but transparent and clear green when in thin chips. This is the dark constituent referred to in the general description of the sand, the red mineral being garnet. It occurs in irregular fragments, varying in size from grains a little larger than the larger garnets down to very small flakes. These latter are very numerous, and can be readily produced by crushing the larger fragments, which are very brittle. The larger pieces are traversed by numerous surface cracks, which are filled with a light-coloured clayey substance:—

Fracture :—Sub-conchoidal, giving rise to moderately sharp edges, where the particles become translucent.

Streak :—A very pale buff.

Hardness :—About 7.

Cleavage :—Cleavage-faces are occasionally present.

Lustre :—From slightly resinous to vitreous on the fractured surfaces.

Specific Gravity :—As in the case of the garnets very difficult to obtain, approximately 3·4 (Joly).

Fusibility:—Easily fused to a black non-magnetic globule.

Blow-pipe reactions:—Soluble in borax; an insoluble skeleton in microcosmic salt.

Solubility in Acid:—Doubtfully attacked by strong HCl.; the acid appeared only to clean the grains by removing the ferruginous colouring material.

Optical Properties:—When mounted in Canada balsam and examined between crossed nicols the thin flakes are found to be doubly refracting, and to possess a moderately high refractive index.

In the absence of suitable appliances no further optical investigation could be made.

No chemical analysis having been made as yet, the mineral may perhaps be placed in the neighbourhood of augite.

4. *Zircon.*—Occurs in the form of small, highly refracting grains. These are either colourless or slightly tinged with brown. They are generally very perfectly rounded, frequently in grains of a cordate form. Not seldom a number of crystal facets were observed, the edges being sharply defined and the faces perfectly plane. The longer edges of the facets are parallel, and although, in the absence of goniometers, and on account of the small size of the crystals, the crystalline form cannot be accurately made out, a powerful lens is sufficient to distinguish the appearance they present from the characteristic octahedral forms assumed by the diamond. There should, therefore, be no difficulty in distinguishing the zircons from diamonds if two or three crystal-facets are present:—

Specific Gravity:—By using a very sensitive spring an attempt was made to obtain a specific-gravity result with the Joly Balance. A result of 4 was obtained but this can only be regarded as extremely approximate.

Hardness:—Well below 8, being readily rubbed down by topaz—but above 7.*

5. *Magnetite.*—This mineral ranks next to zircon in point of relative abundance. A considerable quantity can be readily separated with a magnet. The grains are mostly small in size and differ much in appearance. Many well cleaved† fragments occur. These generally have parallel faces and a high metallic lustre; others are irregular in form and sometimes exhibit the pimply surface characteristic of magnetite; one mammillated piece occurred. The grains are mostly coated to a greater or less extent with ferric oxide, which fact may perhaps account for the somewhat low specific gravity of 4·6 which was obtained for a number of grains taken together.

* This affords a ready means of discrimination from diamond. As the grains are much too small to be held between the fingers, and too much rounded to be held by forceps, the usual method of dealing with small fragments must be followed, viz., attaching to a slip of glass or some similar support by means of a powerful cement. In one instance an apparent cleavage face was obtained by fracturing.

† It is probable that these are not true cleavage face, but planes of separation due to lamellar twinning.

One perfect crystal occurred. This crystal, which had a length of about one millimetre, consisted of the rhombic-dodecahedron modified by faces of the octahedron. The faces of the former were very strongly striated—the striation almost amounting to grooving—as a result of oscillatory combination; the crystal very strongly resembling in this respect, on a small scale, the magnetite sometimes obtained from Nordmarken, in Sweden. Another much less perfect, but apparently similar crystal was found.

6. *Ilmenite.*—Not so abundant as magnetite. Some of the metallic-looking fragments with parallel cleavage, occurring in the sand, are magnetic and also yield feeble titanium reactions. Many of the ilmenite grains are rounded in form, with one cleavage face. The rounded surface is dulled and weathered; the cleavage face bright and metallic, often characteristically striated. The usual blow-pipe reactions are given.

7. *Rutile.*—This mineral is fairly common. It occurs in elongated forms, the length being much greater than the diameter; occasionally also in the form of small cleaved fragments. The fractured ends exhibit a brilliant lustre. The elongated forms, although somewhat rounded, still retain what are possibly indications of crystal edges. In every case the rutile fragments are black and opaque. The streak is grey, and titanium reactions are readily obtainable by the blow-pipe.

8. *Quartz.*—Only abundant in the finest portion of the sand. Several large fragments occurred; of these, some are transparent and colourless with conchoidal fracture and sharp edges, others are dull and rounded and occasionally iron-stained.

9. *Chalcedony and Jasper.*—Some very small fragments of milky chalcedony, reddish jasper, &c., were noticed in the fine material obtained by sifting.

10. *Hematite and Limonite.*—Several large irregularly shaped fragments of dark coloured hematite, and of limonite, with many small grains.

11. *Calcite.*—One colourless fragment of fibrous calcite.

12. *Clay.*—In the form of yellowish nodules. While examining the sifted portion microscopically a few scoriaceous particles were observed; also some composite fragments, the components being black and shining, and red and opaque, respectively.

Numbers 3, 5, 6 and 7, are not always readily distinguishable at first sight. The pyroxenic constituent breaks up into transparent green flakes when crushed; the magnetite and ilmenite yield a black metallic, and the rutile a grey powder when similarly treated. The garnets have been locally taken for ruby, but may, of course, be at once distinguished by their inferior hardness and their fusibility before the blow-pipe.

At present corundum—including ruby and sapphire—tin-stone, brookite, topaz tourmaline, &c., have not been detected.

Having regard to the difference in the character of the quartz grains and the occurrence of a fragment of garnet rock, and of magnetite and ilmenite, it would appear probable that the sand has been divided from the degradation of more than one description of rock.

XXI.—On the Occurrence of *Trigonia semiundulata*, McCoy, in New South Wales, and its significance: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

MARINE FOSSILS of Tertiary age have not hitherto been described from within the geographical boundaries of New South Wales. The Rev. W. B. Clarke* mentioned "Shelly Deposits" in the "far Western interior, beyond the Darling," which he believed to be Tertiary. In the First Edition of the Geological Map of New South Wales†, Mr. C. S. Wilkinson represented a large area of Tertiary rocks in the south-western corner of the Colony, extending from the South Australian boundary up the courses of the Rivers Darling and Lachlan, and along those of the Rivers Murrumbidgee and Murray as far east as one hundred and forty-six and a half east longitude. Later‡ he remarked "The Middle and Upper Miocene marine-beds appear in the banks of the Murray River, on the south-western border of the Colony. They doubtless extend under the Riverina Plains, where they are covered by the Post Pliocene alluvial deposits . . . . . we have no trace of them along our sea board." More recently still he referred to the subject in his "Report on the prospects of obtaining Fresh Water below the surface, in the Districts between the Rivers Lachlan and Darling, and beyond the River Darling," before the Royal Commission on Conservation of Water§, in the following words,—"No. 3. Miocene.—This formation is only seen in the banks of the Lower Darling; but there is little doubt that it extends under No. 2 deposits [Pleistocene and Pliocene], which forms the level country south by a line drawn from Booligal on the Lachlan to Menindie on the Darling, thence west to the South Australian Border." Again Mr. Wilkinson remarked‖ "Area, twenty-two thousand square miles."

Amongst several bores sunk by means of Water-augurs, in the angle formed by the junction of the Murray and Darling Rivers, under the superintendence of

* Sedimentary Forms, N.S. Wales. Third Edition, 1875, p. 51; Ibid, Fourth Edition, 1884, p. 94.
† Ann. Report Dept. Mines of N.S. Wales for 1880 (1881).
‡ Notes on the Geology of N.S. Wales, 1882, p. 56.
§ N.S. Wales Royal Commission Conservation of Water. First Report, 1885, Pt. 2 (Minutes of Evidence), p. 46
‖ *Ibid*, p. 47.

Mr. J. W. Boultbee, Officer-in-charge of the Public Watering Places Branch of the Department of Mines and Agriculture of New South Wales, that at Arumpo, east of the Darling, in the County of Wentworth, is the only one that has yielded any decipherable traces of organic remains. In this bore a *Trigonia*, and another small bivalve, were brought up from a depth of about six hundred and forty-seven feet.

According to Professor R. Tate,* the fossiliferous Murray Tertiaries disappear at Overland Corner, on the River Murray, sixty miles in a direct line from the boundary between New South Wales and South Australia, or one hundred and forty-three miles by the river windings, under cliffs of sand and clay, the two sets of beds being slightly unconformable to one another. On the one hand, we have, to the west, Sturt's fossiliferous formation,† the marine Calciferous Sandstone of Tate, and on the other, to the east, the before mentioned cliffs of sand and clay, also observed by Sturt in his memorable boat voyage down the Murray. Two miles to the east of Overland Corner, Tate describes the following section:—‡

Reddish sands, about	10 feet.
Dirty yellow or greenish sharp sands	10 „
Coarse quartzose, sand-rock, &c....	15 „
Grey, angular, coarse sand	30 „
Hard calcareous sand-rock, with a few Older Tertiary fossils	5 „
	70 „

Professor Tate remarks on this section that it is instructive, "as it is the only one known to me in which the actual superposition of the sharp fluviatile sands upon the marine beds is visible." The fluviatile sands of this section constitute Professor Tate's Newer Tertiary, and the marine beds his Older Tertiary. It is the former set of strata which extends into New South Wales as the formation next in downward succession to the surface Post Tertiary (?) deposits, for Tate adds—"Doubtlessly the whole of the depressed area about the Lower Darling is constituted of Newer Tertiary."§

The older division is now separated by the same Author into the Upper and Lower Murravian Series. The fauna of the former is not copious, principally the "ubiquitous oyster," and amongst other fossils, *Trigonia acuticostata*, McCoy, a shell distinct from that found in the Arumpo Bore. These Newer Tertiaries are believed by Tate to be of Miocene age. The Lower Murravian Series was formerly separated by Tate into two sub-divisions, but it is now regarded by him as one, and possibly homotaxial with the Lower Eocene of European geologists. Its fauna is a very abundant one, and is more or less generally represented by that of the

* Trans. R. Soc. S. Australia for 1883-84 [1885], VII, p. 26.
† Two Exped. Int. S. Australia, Years 1828-31, II, 1834, p. 139.
‡ Trans. R. Soc. S. Australia for 1883-84 [1885], VII, p. 42.
§ Ibid. p. 43.

lower beds at Muddy Creek, Spring Creek, Corio Bay, and Schnapper Point in Victoria, as well as the Table Cape beds in Tasmania.* At most of these localities our Arumpo Bore *Trigonia* is met with.

Applying the above data to the occurrence of this shell in the Arumpo Bore, there appears to be presumptive evidence that we have an extension of the Lower Murravian beds into New South Wales below the Newer Tertiary and Post Tertiaries of the Murray-Lower Darling area. Similar beds in Victoria, are termed by Mr. R. A. F. Murray, Miocene,† and he says that they have recently been proved by boring operations in search of water, "to exist beneath the great plains of the North Western district," *i.e.*, that portion of North-west Victoria, south of the River Murray.

The *Trigonia* now under consideration is *T. semiundulata*, McCoy, and consists of the centre half of a right valve, about the size, or perhaps a little less than one of McCoy's figured examples.‡ It displays a portion of the dorsal margin, posterior slope, and nine radiating costæ instead of ten or eleven, leaving a portion of the slope immediately under the dorsal margin occupied by other semi-obliterated much finer ribs. The concentric rippled rugæ are well marked, and immediately anterior to the siphonal ridge, broken up into almost quadrangular nodes. The siphonal ridge is by far the strongest and widest of the costæ. Internally a portion of the large tooth is preserved.

It appears to me that the radiating costæ on the posterior slope were granulated or toothed, and on comparing an exceedingly well preserved example from Muddy Creek, I find them to be distinctly so. McCoy in his orginal description,§ says that the costæ of the posterior slope are "crossed by lines of growth near the margin, closer and spinulose near the beak." Now, the shell from Muddy Creek proves that the whole of the ribs of the posterior slopes are densely denticulated from the umbones to the posterior margins, and the denticles posteriorly curved, so that when looked at from above they appear as truncated nodes. Furthermore, the concentric undulating rugæ are said to be crossed except on the anterior end, "by rather faint impressed sulci radiating from the beak to the ventral margin." But in the specimens examined by me, these are not sulci, nor are they continuous, but rather a fimbriation of the lower margin of each concentric ruga, and these being placed directly under and above one another in line, give rise to the appearance of sulci, until closely examined.

* Journ R. Soc. N. S. Wales for 1888 [1889], XXII, p. 242.
† Victoria—Geol. and Phys. Geography, 1887, p. 104.
‡ Prod. Pal. Vict., Dec. II, 1875 t. 19, f. 5.
§ Geol. Mag., 1866, III, p.481.

XXII.—On the Occurrence of Basalt-glass (Tachylyte) at Bulladelah: By G. A. STONIER, F.G.S., Geological Surveyor.

In 1887, Professor (then Mr. Geological Surveyor) David announced the discovery of Tachylyte in New South Wales, while engaged in a geological survey of the Vegetable Creek District*. Subsequent to the description of this rock, Mr. Black, of Wallangra near Inverell, sent a specimen of Tachylyte to the late Mr. C. S. Wilkinson, Government Geologist, and it has also been found to occur both at Carcoar and Cowra.†

The specimen, to which the following remarks apply, was collected in the Port Stephens District two years ago, although there has not been an opportunity hitherto of examining the microscope slide.

At Bulladelah a large deposit of alunite occurs forming the summit of a prominent hill behind the township; a considerable tonnage of mineral has been quarried, some of which was treated locally, and the remainder was shipped to England. The Tachylyte was found at the southern extremity, and at the foot of the hill, with several loose fragments of andesitic pitchstone, mostly about three inches, one block, however, being twelve inches in diameter. Time did not permit of their being traced to the place whence they have been derived, although the parent rock cannot be far distant. The rocks in the locality are both sedimentary and eruptive; the former are probable referable to the Carboniferous System, but the latter have not been investigated.

In hand specimens the rock appears to be compact, but when examined with a fairly powerful lens, small gas pores can be detected. The colour of freshly broken surfaces is black with a resinous lustre inclining to vitreous; joint faces are bluish-black, occasionally iridescent. The fracture is sub-conchoidal. Thin splinters fuse readily to an opaque black bead, and the powdered rock is very feebly magnetic. Two determinations of the specific gravity were made with a Walker's Balance, and found to be respectively 3·16 and 3·17. The average density of Tachylyte is about 2·7, but is variable as the following figures show§ :—

Iceland—2·53, sideromelane.

Sasebühl—2·58, tachylyte.

Sandwich Islands—2·71, basalt glass (six varieties).

Beal (Western Islands, Scotland)—2·72, basalt glass.

Some do do 2·89, do

* Proc. Linn. Soc. N.S. Wales, 1887, II, (2), p. 1078.
† J. Milne Curran, Journ. R. Soc., N.S. Wales, 1891, XXV, p. 200.
§ Judd & Cole, Quart. Journ. Geol. Soc., 1883 XXXIX, p. 449.

All the specimens examined had a specific gravity markedly lower than the Bulladelah example, and it is possible that the latter may be a glassy form of an ultrabasic rock.

Under the microscope the principal constituent is an isotropic glass, fairly translucent and containing globulites, microlites, and skeleton crystals. By transmitted light the glass is seen to have been originally of a dull slightly yellowish-brown colour, due perhaps to dusty magnetite, which has been abstracted in parts to help to form microlites, &c., and in these places the colour is a clear yellow. If the quarter-inch objective be used, a sub-perlitic structure is discernible, due to a number of fine cracks, some of which are curved and concentric. Gas pores are fairly numerous and of various sizes up to four-tenths of a millimetre in diameter. The microlites are peculiar and exceptional. They are very abundant, and under a low power seem to be all black and opaque. The most noticeable are long spicular bodies, slightly translucent at their extremities; they run in various directions, intersecting each other at various angles, and are generally surrounded by a rather indistinct absorption halo. Besides the long microlites there are others of a similar character although of a shorter habit, which are collected into aggregates having a parallel arrangement, but making various angles with the longer axis of the crystal they are commencing to form. Rosenbusch has figured a similar example*, and considers them to be hornblende microlites. Distinct from those which have already been referred to, are some minute crystals and grains arranged in straight lines so as to form rods, which intersect each other at right angles and give various figures, from a simple cross to more complex forms. These are composed of magnetite, and in places show a good dendritic structure. Spherulites and trichites are not represented, nor are there any porphyritic minerals. Under a high power clouds of globulites appear, and the crystallizations are seen to be varied; the long spicules are made up of a number of small microlites frequently simulating a quiver of arrows, while on their sides are fern-like excrescences. The absorption halos also become more distinct.

The above description represents the general character of the slide, but in one portion there are clear microlites distributed through a greyish-black ground mass and surrounded by a ring of greyish-black and colourless microlites crossing each other in various directions, with an outside setting of long spicular hornblendes having a roughly radial arrangement.

The pitchstone shows both well developed fluxion and perlitic structure, with a fair sprinkling of allogenic crystals of triclinic felspar and corroded fragments of andesitic lava.

* Vol. I, pl. III, fig. 3.

XXIII.—On Palatal Remains of *Palorchestes azael*, Owen, from the Wellington Caves Bone-deposit: by W. S. DUN, Assistant Palæontologist and Librarian.

[Plate XVI.]

I.—Introduction.

THE type specimen of the genus *Palorchestes* was discovered in 1851 by Dr. Ludwig Becker, in Pleistocene deposits in Victoria, and was described by the late Sir Richard Owen*. This specimen consisted of the anterior portion of the cranium with the five cheek-teeth *in situ*. In the 'British Museum Catalogue of Fossil Mammals,'† Mr. R. Lydekker mentions a "cast of the palatal region of the cranium, showing the five cheek-teeth of either side" (M. 2,573), as presented by Professor Ramsay‡. This specimen was found in the Wellington Caves, and another cast of this fossil is in the Mining and Geological Museum, Sydney, mention of which will be made later on. The specimen about to be described was found in the Wellington Caves, by Mr. James Sibbald, the Keeper, who is most energetic in his search for remains, and has already succeeded in unearthing a large number, some of which it is hoped will be reviewed later on. The specimen in question was found in 1891 in the bone bed of No. 4 Cave. This cave, Mr. W. S. Leigh, Superintendent of Caves, informs me, is on practically the same level as others from which previous supplies of Marsupial remains have been obtained, and is a small chamber leading off from the larger caves. As far as I can ascertain, these—the British Museum, Australian Museum, and Geological Survey Collection specimens—are the only cranial examples of *Palorchestes* that have as yet been found, though deposits of the same age in Queensland have yielded specimens of the mandibles, and other portions of the skeleton, which from their relative size seem to be more nearly allied to *Palorchestes* than to any other known Macropod. A list of these specimens and references to their literature will be found in the British Museum Catalogue,§ and Mr. C. W. De Vis has recorded a specimen of the jaw of *Palorchestes* from St. Ruth, Darling Downs, Queensland.‖

II.—Description of the Specimen.

Our specimen consists of a portion of the palatal region of the cranium showing nearly all the bony palate and the hinder two-thirds of the maxillaries, with the premolar, p^4, the first three molars on each side *in situ*, and the anterior half of the alveoli of the right and left fourth molars. The teeth are in a singularly good state of preservation, as is usually the case with specimens from the Wellington Caves bone-breccia, being much more perfect than in the type specimen from

* Phil. Trans. R. Soc., 1874, CLXIV, pls. 81, 82, 83; Phil. Trans. R. Soc., 1876, CLXVI, pl. 20; Extinct Mam. Austr., pl. 97, fig. 1; Proc. R. Soc.; 1873, XXI; 1875, XXIII.
† Pt. V, p. 238.
‡ Dr. E. P. Ramsay, Curator, Australian Museum, Sydney.
§ *Op. cit.*, p. 238, and *inter alia*, pp. 239, 241, 242, 244, 245.
‖ Proc. Linn. Soc. N. S. Wales, 1883, VIII, Pt. 2, p. 221.

Victoria. The maxillary suture is well marked and comparatively simple. The palato-maxillary sutures are clearly marked and more complex. In this specimen the palatines reach a point nearly opposite to the anterior border of m^3, whereas in the type specimen they extend to about the middle of the same tooth. The lateral anterior angles of the suture are rounded, and the palatines narrow slightly posteriorly, whereas in *Macropus* the anterior lateral angles are projected forward or straight, and the palatines increase slightly, instead of narrowing, towards their posterior margin. The palatines likewise appear to have apertures in them at the anterior angles, as is the case with existing species of *Macropus*. Unfortunately, the posterior margin of the palate is imperfect, but it would appear to be slightly concave. Opposite the premolars are the openings of two vascular foramina in the maxillaries, directed backwards. The cheek teeth form an open curve which widens posteriorly. Portion of the maxillary pier of the right zygomatic arch is preserved, and agrees with the description of that part in the type specimen. On the cranial surface traces of the narial septum are preserved, disappearing at a point about opposite to the roots of m^1. The "blind fossa" mentioned by Sir Richard Owen is well preserved.

Premolar, P^1.—This tooth is triangularly-ovate in shape, the apex being directed inwards. It is divided into two portions, an outer and an inner, by a longitudinal depression. The outer ridge which is the more largely developed of the two is composed of two lobes, an anterior and a posterior, connected by a narrow mid-link. The working surface is small and more marked on the fore part. The left premolar, though it presents the same general form as the right, does not show its division into anterior and posterior lobes so clearly. On the outer aspect there is a well-marked groove separating these two portions, and it is also developed on the inner slope. On the anterior face there is a well-marked groove running towards the crown and ending in a depression, and a fainter one on the anterior curve. The prebasal ridge is continued to the anterior angle of the inner lobe. There is also a well-marked post-basal ridge which commences about one-third up the posterior lateral angle of the outer lobe and is continued to the posterior angle of the inner lobe. The sulcus dividing these two lobes is well marked, and is bounded before and behind by the pre- and post-basal ridges. The two lobes are connected to about two-thirds of their height. The crown of the inner lobe is worn into a narrow elongated surface parallel to the curve of the molar series. There are two roots, the hinder is large and oblong ovate, tapering slightly and in the same plane as the posterior face of the tooth, and slightly hollowed down the median line. The anterior root is much smaller, tapering down to a point, and is directed slightly forwards. The enamelled surface is smooth and not corrugated. The following measurements give the relative proportions of the right premolar—length, 21·5 mm.; breadth, 19 mm.; length of outer lobe without ridges, 17 mm.; length of inner lobe without ridges, 14 mm.

First Molar, M^1.—The first molar has two well-marked lobes, an anterior and a posterior. In form it is oblong-ovate. Dividing the teeth in two along the main valley it will be seen that the anterior lobe is slightly the larger, and has a well-developed pre-basal ridge extending from the median line round the inner anterior angle of the tooth, and has a width of 2·5 mm. At the outer corner there is the commencement of the outer half of the pre-basal ridge, which runs out almost immediately in consequence of a strongly-marked hollow in the enamel. The margins of this depression form an island, which is almost surrounded by a thin band of cement continuous with the worn surface of the fore-lobe. Connecting the anterior and posterior lobes is a mid-link. The outer half of the main valley slopes up gradually to the mid-link, and the outer enamel is constricted to form an oval depression three mm. long. The inner portion of the main valley is directed slightly forwards at the mid-link, and is divided into two portions and an outer and an inner by a ridge on the sides of the anterior and posterior lobes; the inner portion is considerably deeper than the outer. At its inner and outer aspects the main valley is bounded by a slight elevation of the enamel, more especially marked on the inner. The post-basal ridge is well marked. There is a slight groove along the median line of the posterior lobe. Measurements of right first molar—length, 27·5 mm.; breadth, 22 mm.

Second Molar, M^2.—This tooth, as will be seen from the measurements, is slightly larger than m^1, and is more simple in structure. The fore-lobe is slightly the wider. There is a well-marked pre-basal ridge commencing at the anterior outer angle and continuous round the inner curve of the fore-lobe, being interrupted in the median line by a ridge running up to the working surface. As in m^1 the inner half of this ridge is the more marked. The front slope of the tooth bears slight traces of ridging. The mid-link is well marked, and the main valley is of the same nature as in the preceding tooth. There is a well-marked tubercle at the outer margin of the main valley. The post-basal ridge is not so well marked as in the preceding tooth, and is confined to the outer half of the posterior aspect of the tooth. There is a median groove as in m^1, and on the inner side of it there is a bulging of the tooth more marked than in m^1. Length, 28·5 mm.; breadth, 23·5 mm.

Third Molar, M^3.—This tooth is more elongate and slightly narrower than m^2. The general form is of the same type as in m^2. The pre-basal ridge is not so marked on the outer side, and the mid-link is placed at a lower level, due to the less worn state of the anterior and posterior lobes. The tubercle at the outer opening of the main valley is more marked than in the preceding tooth, and the ridge on the sides of the inner portion of the main valley, which are so well marked in m^1 and m^2, are absent. The post-basal ridge is still less developed, and is confined to the outer half of the hinder aspect of the posterior lobe. Length of tooth, 29 mm.; breath, 23 mm.

The following is a tabular comparison of the relative proportions of the three specimens already mentioned—that described by Sir Richard Owen in the Philosophical Transactions for 1874, the specimen from the Wellington Caves, now first recorded, and a cast of another specimen from the Wellington Caves in the possession of the Australian Museum:—

	Owen's Type.*	Wellington Cave Specimen.	Australian Museum Specimen (cast.)
Length of molar series p^4 to m^4	120·5	.....	123·5
Length of p^4 to m^3	92·5	106·5	96
Length of p^4	19	21·5	18·5
,, m^1	22	27·5	24
,, m^2	25·5	28·5	26·5
,, m^3	26	29	27
,, m^4	28	.....	27·5
Palate, breadth outside m^3	102	106·5	103
Palate, breadth outside m^2	59·5	57	57
Palate, breadth outside p^4	77	82·5	79
Palate, breadth inside p^4	54	47·5	46·5

III.—Conclusions.

The general condition of the teeth is, as before remarked, very well preserved and their appearance would lead one to infer that they belonged to an aged animal, though their relatively little worn condition would point to the fact that m^4 had not long come into position. Certainly it is not represented in the specimens, but the remains of the alveolus shows that it had been cut. As pointed out by Mr. Lydekker pm^4 resembles that of *Sthenurus*—with which he regards *Protemnodon* to be synonymous, and has accordingly classed *Protemnodon anak*, Owen, under *Sthenurus atlas*, Owen†,—in possessing an inner lobe, and wearing to an oval surface, and having no marked secant edge. The surface enamel of the molars resembles that of *Sthenurus* also in that it is not folded, a point in which *Palorchestes* differs from *Procoptodon*. In *Sthenurus* the connecting link between the fore and hind lobes of the molars is not well marked as is pointed out by Mr. Lydekker, and shown in the plate‡ in the 'Fossil Mammals of Australia,' and in the figure§ in the British Museum Catalogue. In our specimen of *Palorchestes* this, however, is well marked as will be seen by the figure. The pre-basal ridge or talon in *Sthenurus* has no bridge connecting it with the forelobe whereas in our specimen there is. In the British Museum Catalogue it is stated that "the true molars have no distinct anterior talon"‖, and a little further on, "in the absence of an anterior talon, the upper true molars resemble those of the existing *Macropus magnus*," but these statements seem hardly borne out by the specimens before us, as both the examples

* Measurements taken from 'Fossil Mammals of Australia,' pl. XCVII, fig. 1. All measurements in millimetres.

† *See* footnote, B. M. Cat. Foss. Mam., V, pp. 231 and 232.

‡ Pl. 83, f. 8.

§ Vol. V., f. 37.

‖ *Op cit.*, p. 237.

from Wellington Caves and the figure of Owen's type show one, though certainly not marked to a large degree as in the case of ***Macropus brehus***, Owen (***Sthenurus brehus***, Owen*).

Sir Richard Owen considered that *Palorchestes* occupied a position between the existing *Macropodidæ* and *Nototherium* and *Diprotodon*†. Mr. C. W. De Vis‡ is of opinion that this genus is more nearly allied to *Sthenurus* than to *Macropus* or *Procoptodon*. From a consideration of the relative differences of the upper premolar and molars it would seem to resemble *Sthenurus* in the form of the premolar, while the molars possess characters in common with *Macropus brehus*, Owen (as defined in the British Museum Catalogue), and *Procoptodon*. It must be pointed out that, in the plate, lines are shown on the outer and inner surfaces of the molars, these are meant to represent cracks in the enamel alone and not ridging or grooving.

XXIV.—Mineralogical and Petrological Notes—No. 1: by GEORGE W. CARD, A.R.S.M., &c., Curator and Mineralogist.

I.—Contents.

1. Haloid Silver minerals from Peak Hill.
2. Crystallised Pyrite from Mount Stewart.
3. [Spadaite] from Marulan District.
4. Inclusion of Mispickel in Quartz; 4A Doubly-terminated crystals of Quartz; 4B. Rock Crystal from Kingsgate, with a note by E. C. Whittell, Field Assistant.
5. Chocolate nickel ore from New Caledonia.
6. Quartz Felsite containing crystals of Mispickel from Sunny Corner.
7. Volcanic Glass from Tweed River District.

II.—Introduction.

Many specimens of minerals and rocks are submitted to the Geological Survey Branch for examination, or are added to the collections in the Mining and Geological Museum. It must necessarily be the case that points of interest arise from time

* Extinct Mam. Australia, pl. 109, f. 4, and B. M. Cat. Foss. Mam., V, pp. 207, 208.
† Extinct Mam. Australia, p. 470.
‡ *Loc. cit.*, p. 224.

to time, and it is now proposed to record these in the form of brief Mineralogical and Petrological Notes. Nothing like a complete description will be attempted under this heading, but the occurrence will be recorded, and such leading particulars given as may be useful to persons engaged in the mining industries of the Colony, and to others interested in geology. It is hoped to continue the "Notes" at frequent intervals.

III.—Mineralogical Notes.

1. *Haloid Silver Minerals from Peak Hill.*—Early in the present year specimens of auriferous ore were received from the Welcome Mine, Peak Hill, in which these minerals were present in considerable quantity.

The ore is of the brecciated character usual in this district, the silver minerals being present in the form of a thin greenish-yellow coat. A number of tests were made with the blow-pipe with the result that bromine was detected in considerable quantity in examining one piece of the ore, but in every subsequent experiment only iodine could be found. A qualitative analysis showed that the silver was present principally as chloride, but that some iodide also occurred; no bromine was detected. An assay yielded 20½ oz. of gold, and 140 oz. of silver.

The analysis and assay were made under the superintendence of Mr. J. C. H. Mingaye, the Analyst and Assayer.

2. *Crystallised Pyrite from Mount Stewart.*—An exceptionally fine specimen of crystallised iron-pyrites has recently been added to the Mining and Geological Museum by the favour of the Mount Stewart Lead-and Silver-mining Company. The block is very massive, and measures fourteen by eighteen inches. The crystals consist principally of very perfect cubes, which are not modified by faces of other forms. Every dimension of cube, up to 1$\frac{1}{16}$ inch edge, occurs: the faces frequently exhibit the striations characteristic of this mineral, interpenetration—twinning is rare, and a curious etching is present on some of the faces. The faces of the pentagonal-dodecahedron occurs but rarely, and always imperfectly developed. A few quartz crystals with a long prismatic habit occur on one side of the specimen, and in druses. Unfortunately some of the crystal edges have been damaged by a fall in the mine.

3. [*Spadaite.*]—A clay, resembling in character the substance described* by Dana as spadaite, from the Marulan District. It is a soft flesh-coloured, non-plastic substance with a soapy feel and imperfectly conchoidal fracture, occurring in nodules in a brownish soapy clay which is traversed by veins of oxide of manganese. It is slightly waxy in colour, and adheres but little to the tongue. In water it rapidly falls to pieces with copious liberation of air-bubbles, but does not make a paste; heated in the blow-pipe flame, it does not decrepitate, but fuses readily with much

*E. S. Dana, A System of Mineralogy. Sixth edition, 1892, p. 682.

intumescence to a glass varying from colourless to green; when first fusing it glows brilliantly, sometimes with a slight fluorescence; no colouration is obtained with nitrate of cobalt. Heated moderately in a crucible it becomes brittle, but without change of colour. It easily gelatinises in hydrochloric acid, and yields much water in the glass tube. Hardness, about 2. A qualitative analysis, made by the Analyst and Assayer, gave the following results:—Soluble in hydrochloric acid; consists of a hydrated silicate of iron, alumina, and magnesia, with a small quantity of manganese probably existing as MnO.*

4. *Inclusion of Mispickel in Quartz.*—From the Kingsgate Mines, near Glen Innes. The best specimen is a portion of a fairly large crystal of quartz. Two prism-faces are preserved, the width being about fifty millimetres (two inches), and the transverse striations very distinct. The crystal is otherwise every much broken. It is tolerably clear internally, but discoloured on the outer surface.

The inclusions of mispickel occur in one portion of the crystal, and are in ribbon-like form. In one case it forms a sort of axis with projections on one side, but the greater part is arranged in a radiating manner from a central nucleus. The radiating filaments may either be drawn out approximately in the direction of the principal axis of the quartz crystal, or are twisted in various directions. Here and there the inclusions emerge on a surface of fracture, and sufficient material can be obtained to determine the presence of arsenic and iron.

4A. *Doubly-terminated Crystals of Quartz.*—Also from Kingsgate. One large and several smaller crystals have been obtained. The large specimen has the following dimensions:—Total length three hundred millimetres (eleven and a half inches); length of prism one hundred and sixty millimetres (six and a quarter inches); length of each termination about seventy millimetres (two and a half inches); diameter of crystal from the centre of one prism-face to another about one hundred millimetres (four inches). The development of the rhombohedral faces is not very unequal. Oscillatory combination is very strongly marked, both on the prism- and the rhombohedron-faces, the edges of the prisms more especially, being very irregular in consequence. The crystal is dull externally and nearly opaque; internal reflections giving rise to prismatic colours on the faces of R. Both the apices are slightly damaged. The smaller specimens are each about sixty-four millimetres in length. One of them has a tabular habit owing to the great development of certain faces. All are translucent, and two are somewhat smoky.

4B. *Rock-Crystal from Kingsgate.*—A considerable quantity of rock-crystal has been obtained. Some of the smaller pieces were perfectly clear, and would probably be quite good enough for optical work were they a little larger. Most

* The presence of manganese might be accounted for by the occurrence of the veins mentioned above.

of the larger blocks, although very clear, display the prismatic colours produced by internal reflection resulting from internal cracks; in some cases this was only a surface feature, but in others the interior was affected, the specimens being thus rendered unfit for the manufacture of "pebble" glasses.

Not much rock crystal is used in the Colony, but a small quantity is imported; it remains to be proved whether this demand might not be locally supplied.

The specimens from Kingsgate, just described, were brought down by Mr. E. C. Whittell, who has kindly supplied me with the following information regarding their mode of occurrence. "The quartz and rock-crystals were obtained from the Old Kingsgate Bismuth Mine, about twenty-two miles north-west from Glen Innes, from what appeared to be pipe-veins . . . and segregated irregular masses—some of considerable extent—in granite. Some of the workings seemed to yield little else but rock crystal; tons of this material being at grass. In mining, the crystals, with but few exceptions, had been broken considerably, so that I was unable to procure any of large size. Much of the mineral seems to be of good quality for spectacles, &c. Those specimens containing inclusions of arsenical pyrites . . . were of rare occurrence and were to be found in those heaps which consisted chiefly of quartz and rock-crystal."

5. *Chocolate Nickel Ore, from New Caledonia.*—Specimens of this ore have lately been received from New Caledonia, and are now in the Geological and Mining Museum. Several of the specimens contain the green as well as the brown variety of the ore. These are associated in such a way as to suggest a passage from one to the other. In one case it would appear as if the green mineral had undergone such a change, as residual patches of it remain surrounded by the brown.

Two assays and qualitative analyses were made under the supervision of the Assayer and Analyst, with the following results:—

1. Chocolate nickel ore from a depth of 100 metres. Mine Bienvenue, Nakety.

Protoxide of nickel	19·37	per cent.
Equal to metallic nickel	15·23	„

2. Chocolate nickel ore, Mine La Renaissance.

Protoxide of nickel	18·50	per cent.
Equal to metallic nickel	14·55	„

On qualitative analysis "these minerals were found to consist largely of ferric oxide, magnesia, nickel oxide, silica, and a small percentage of chrome iron ore."

6. *Quartz-Felsite containing crystals of Mispickel, from Sunny Corner.*—This is a pale greenish rock mottled with white where undergoing kaolinisation. It is very compact.

Many very perfect little crystals of mispickel are embedded in the rock. These have an average length of 1·5 millimetres, and occur singly for the most part, but are sometimes arranged in stellate and in cruciform twin-groups. The readiness with which the crystals of mispickel become detached from the rock renders the preparation of a thin section very difficult, but Mr. C. Murton, the Lapidary, has succeeded in producing a slice transparent enough for microscopic investigation. The rock is found to consist of a hemi-crystalline groundmass in which fragments of quartz, none of which are idiomorphic, are contained. In the thicker portions of the section what appears to be a true flow structure may be seen, but where thinner the groundmass can be resolved into the minutely granular polarising areas characteristic of quartz-felsite. The rock would appear to be a somewhat devitrified acid eruptive mass. An assay by the Analyst and Assayer yielded three ounces of silver and three penny-weights of gold.

7. *Volcanic Glass from the Tweed River District.*—An acid volcanic glass, in which many porphyritic crystals of quartz and felspar occur, has been several times brought in with a view to its containing tinstone. The mistake arose from the unusual brownish-red colour assumed by the quartz when weathered, and was by no means an unnatural one. Here and there the doubly-terminated crystals of quartz are to be seen very clearly.

A special point of interest arises from the glassy nature of the magma, a vast number of crystallites, globulites, margarites, clavalites*, &c., being developed.

Perlitic structure is beautifully shown on the weathered surfaces, the weathering resulting in the production of spheroidal masses. This, and other similar rocks from the same locality will be fully described and illustrated at an early date. This rock should prove of considerable utility for educational purposes.

XXV.—Note on an Aboriginal Skull from a Cave at Bungonia: by R. ETHERIDGE, Junr., Palæontologist and Librarian.

SOME time ago a human skull was found under peculiar circumstances, by Mr. Louis Guymer, Keeper of the Bungonia Caves, in a small cave, about four hundred yards in a northerly direction from the top of the "Look-down," at Bungonia. The skull was ultimately transmitted to the Department through the Superintendent of Caves (Mr. W. S. Leigh).

* F. Rutley, Min. Mag., 1891, IX, p. 263.

The Bungonia Caves are situated in the Parish of Inverary, County of Argyle, about thirteen miles from Marulan and twenty-four from Goulburn. "The Look-down is on the top of the out-crop of the limestone in which the caves occur, and from this position a magnificently picturesque view is obtained, looking into the Shoalhaven Valley at its junction with the Jerrara Creek, where there is almost a sheer drop of over of a thousand feet, the precipice being formed by the lime-stone, which dips towards the main valley"*

About twenty feet within the mouth of the cave, says Mr. Guymer, there is a drop of ten feet, then a small chamber, with the floor dust covered. Twelve feet within this chamber in a westerly direction was observed a large overhanging rock, and under this the skull was found. It rested on a skin of some kind, then rotten with age, face downwards, and was immediately covered with a net. This was overlain by some stringy-bark, and above the whole flat stones were piled. No other human bones were discovered, but a number of smaller ones, probably wallaby. The position of the skull was at least forty feet under ground in a direct line. The cave is said to have been years ago, the haunt of bushrangers.

As the occurrence of this skull, under the circumstances cited, and supposing it to have been aboriginal, opened up certain interesting traits in the character of the blacks, it was of importance to ascertain to which of the two races now inhabiting the country it appertained. With this in view the specimen was placed in the hands of Prof. J. T. Wilson, M.D., of Sydney University, who has very kindly supplied the following measurements:—

Cubic capacity	... cubic centim.	1,233
Longitudinal cranial diameter (glabello-occipital)	m.m.	178
Transverse maximum diameter (in parietal region)	„	121
Vertical diameter (basi-bregmatic)	„	126
Cephalic index		70
Total horizontal circumference	m.m.	473
Vertical transverse arc (supra-auricular)	„	277
Bizygomatic width	„	109
Ophryo-alveolar height	„	66
Facial index		60
Narial height	m.m.	38
„ width	„	24
Narial index		63
Orbital height	m.m.	32
„ width	„	35
Orbital index (megaseme)		91
Facial angle (with Broca's Facial-lateral Goniometer)		83°
Projection of anterior cranium, total	m.m.	87
„ „ facial	„	4
„ of posterior cranium	„	93

* Anderson, Ann. Report, Dept. Mines, N. S. Wales for 1889 [1890], p. 232.

The skull is that of an aboriginal child, and says Prof. Wilson, characteristically Australian, about eight years of age, the first permanent molars present, and the permanent lateral incisors just appearing. It is markedly dolichocephalic and strongly platyrhine. The sex is doubtful.

The foregoing details amply prove the skull to be that of a young aboriginal, and this is well borne out by its surroundings in the cave—the net, bark, and stones. Very little notice need be taken of the presence of bushrangers at one period, for it is exceedingly unlikely that they would have exercised the same care and attention to detail as that shown by those who placed the skull in the cave. The use of bark and stones in disposing of human remains amongst the Aborigines has been repeatedly described, and as regards the net, a portion of which I have examined, there can be no possible doubt of its aboriginal origin. It consists of a two-ply string made of fibre, and stained dark brownish-red. The mesh is a very loose one, each loop crescentric-triangular, an excellent illustration being that given by the late Mr. R. B. Smyth, in his work on 'The Aborigines of Victoria,' of a hand fishing-net from Lake Tyers, Gippsland.* It was known to the Lake Tyers natives under the name of *Lowrn*, and is likewise identical with the mesh of a Tasmanian "basket or bag" preserved in the Oxford University Museum.† It is the same stitch as that used at the present day in ladies fancy work, and is technically known as the "plain net or first lace stitch."

Now the chief interest attached to the discovery of this skull centres itself in the well known dread of caves exhibited by the Aborigines, a dread even handed down to the half-castes. Unless under very exceptional circumstances few Australian blacks can be induced to enter one of these places, and we can only come to the conclusion therefore, that this occurrence is one of those exceptions. Another point requiring solution is—why was the skull only placed there, to the exclusion of other parts of the body, more particularly in connection with the manifest care bestowed on it?

Touching the reluctance of the blacks to enter caves we have the testimony of Henderson, who states in his 'Observations on the Colonies of New South Wales and Van Diemen's Land,'‡ that around Wellington (New South Wales), "the natives entertain a superstitious dread of entering any of the caves in the limestone rock." Again, our leading authority on all matters aboriginal, Mr. A. W. Howitt, in describing his exploration of the Mitchell River, in North Gippsland, mentions the wonderment of his sable companions, Turnmile and Bungil-Bottle, at the stalactite caverns on Dead-cock Creek, regarded by them as the "haunt of the mysterious creature, the 'nargun,' the 'nargun a narguna', or 'den of the nargun.'"§ During a recent examination of the Cooleman Caves,

* Aborigines of Victoria, 1878, I, p. 389, f. 223.
† Ling Roth, Aborigines of Tasmania, 1890, p. x, f. 3.
‡ P. 160 (8vo. Calcutta, 1832).
§ Progress Report Geol. Survey Victoria for 1875 [1876], p. 220.

on Cooleman Creek, at the head waters of the Goodradigbee River, by Mr. R. A. Barber, of Humewood, Yass, Mr. W. S. Leigh, Superintendent of Caves, and the Writer, nothing would induce our half-caste guide, Dick Low, to enter the caves with us. By the Watchendie Tribe, at Shark's Bay, Western Australia, all caves are looked upon as the abode of malevolent spirits called *Ingnas*, the souls of departed blacks, who have not received the correct rites of sepulchre, and are shunned as much as possible.* Mr. A. Oldfield, the writer of the previous passage, adds, "Nearly every cave gives a shelter to an *Ingna* of the ordinary kind, and such places are only resorted to during violent thunder-storms, and then merely to hide themselves from the fury of a spirit more dreaded than those haunting such localities." Guided by these facts it would appear that the dread of entering caves, although widely spread, was not absolutely universal amongst the Aborigines—for Howitt's companions do not seem to have entertained fear. We can only conclude that the presence of this skull in the Bungonia Cave points to the depositers as an illustration of the exceptions to the rule, for the evidence, such as it is, seems to indicate the surroundings of the skull as aboriginal. It must not be inferred that any connection whatever is intended between caves in the strict sense of the word, and the *Gibber-gunyahs*, or Rock-shelters, and invariably exposed to the light of day. The use of these is well known and thoroughly understood—that of places of habitation.

Mr. W. W. Froggatt, when collecting at Kimberley, N. W. Australia, observed the habits of the blacks of that region. He says† "They build no mi-mis, as they obtain complete shelter in the numerous limestone caves," that is, in the cave entrances, for Mr. Froggatt tells me they will on no account penetrate beyond, into the inner recesses.

An authenticated case of a black taking to a cave is that of the mummified remains discovered in one of the inner-chambers of the Mosquito Plains Caves, near Mount Gambier, South Australia, and recorded by the late Rev. J. E. T. Woods‡. It appears this man was a survivor from a "dispersal," and being wounded crept further and further into the cave to die, where the corpse became "almost petrified by the droppings of the limestone." It was known to have been in that position for many years.

The only other instance known to me of human remains found in an Australian cave is the mention by the late Mr. Gerard Krefft§, of "bones of the extremities found in a cave at Wellington, being left and right femur, left and right tibia, left and right humerus, portion of fibula." These were found in No 2 Cave at

* A. Oldfield, Trans. Ethnol. Soc., 1865, III, p. 236.
† Proc. Linn. Soc. N.S. Wales, 1888, III (2), p. 651.
‡ Geol. Obs. S. Australia, 1862, p. 329.
§ Australian Vertebrata (Recent and Fossil), &c., 1867, p. 91.

Wellington, by Mr. Henry Barnes, Articulator, &c., to the Australian Museum, Sydney, and were those of a "gin." The bones were not petrified, and appeared to have been casually washed in from the surface.*

It would seem, therefore, definite evidence to the contrary being absent, that this is a genuine case of the deposition of aboriginal remains sufficiently far within a cave to be an exception to the general rule previously referred to.

XXVI.—The Australian Geological Record for the Year 1892, with Addenda for the Year 1891: by R. ETHERIDGE, Junr., Palæontologist and Librarian, and W. S. DUN, Assistant Palæontologist and Librarian.

I.—Record for 1892.

ANDERSON (W.):—

Progress Report by Mr. William Anderson, Geological Surveyor. *Ann. Rept. Dept. Mines and Agric. N. S. Wales for* 1892, pp. 121–125, with map and section.

Geological Map of part of the Elrington (Major's Creek) Gold-field. Scale, 10 chains to 1 inch. *Ann. Rept. Dept. Mines and Agric. N. S. Wales for* 1892.

On the General Geology of the South Coast, with Petrological Notes on the Intrusive Granites, and their Associated Rocks, around Moruya, Mount Dromedary, and Cobargo. *Records Geol. Survey N. S. Wales*, 1892, II, Pt. 4, pp. 141–165, pls. 8–10.

Notes on the Occurrence of Opal in New South Wales. *Records Geol. Survey N. S. Wales*, 1892, III, Pt. 1, pp. 29–32.

ALADDIN'S LAMP CLAIM, LUCKNOW.—The Aladdin's Lamp Claim, Lucknow. *Austr. Mining Standard*, 1892, VII, No. 189, p. 365.

AUSTRALIA—HANDBOOK—The Australian Handbook [Gordon and Gotch], &c., for 1892. [The Phys. Structure and Geology of Australia, pp. 116–119; N. S. Wales, Mining, pp. 150–151; Victoria, Geology, p. 228; Mining, pp. 232–233; S. Australia, Geology, pp. 312–313; Mineral Resources, p. 316; Northern Territory, Mineral Resources, pp. 353–354; Physical Geography, pp. 355–356; Geological Formation, pp. 357–359; W. Australia, Geology,

* See a discussion of this subject—Etheridge, Proc. Linn. Soc. N.S. Wales, 1890, V (2), p. 264.

p. 368; Mineral Resources, pp. 369–370; Queensland, Geology, p. 389; Mineral Resources, p. 392; Tasmania, Geology, p. 441; Mineral Resources, pp. 443–444.]

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1A. PITTMAN, E. F. Report on Site for new Bore at Cremorne, pp. 109, 110, with map

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WOODWARD (A. S.):—

Catalogue of the Fossil Fishes in the British Museum (Natural History), Cromwell Road, S.W., Part II. [*Asterolepis australis*, F. McCoy, p. 207; *Gosfordia truncata*, A. S. Woodward, p. 275; *Apateoeplis australis*, A. S. Woodward, p. 486; *Myriolepis Clarkei*, Egerton, p. 515; *Coccolepis australis*, pp. 525, 526.]

On the Discovery of a Jurassic Fish Fauna in the Hawkesbury—Wianamatta Beds of New South Wales. *Brit. Assoc. Rept. for* 1890 [1891], p. 822.

XXVII.—A Locality Index to the Reports of the Geological Survey of N. S. Wales from 1875 to 1892 inclusive: by W. S. DUN, Assistant Palæontologist and Librarian.

THE Reports of the Officers of the Geological Survey Branch of the Department of Mines, New South Wales, appear in the Annual Report of the Department.* With the view of facilitating ready reference to the localities mentioned therein, the Compiler has prepared the following Locality Index to the Reports from 1875 to 1892, inclusive.

The system adopted is the following:—First, the name of the locality is given; second, the initials of the Author of the Report; third, the year *for* which the Report is published; and fourth, the page on which the information is to be found.

It must be borne in mind that these Annual Reports contain Reports on work done in a given year and are published in the next, *e.g.* the Annual Report for 1875 bears the publication date of 1876, and so on.

I.—Initials used.

C.S.W.—The late Charles Smith Wilkinson, Geological Surveyor in Charge.

E.F.P.—Edward Fisher Pittman, formerly Geological Surveyor, then Chief Mining Surveyor, now Government Geologist.

T.W.E.D.—Tannet William Edgeworth David, formerly Geological Surveyor, now Professor of Geology and Natural History, University of Sydney.

H.Y.L.B.—Henry York Lyell Brown, formerly Geological Surveyor, now Government Geologist, South Australia.

L.H.G.Y.—The late Lamont Henry Græme Young, formerly Geological Surveyor.

W.A.—William Anderson, late Geological Surveyor.

R.E.—Robert Etheridge, Junr., Palæontologist and Librarian.

J.E.C.—Joseph Edward Carne, formerly Curator and Mineralogist, now Geological Surveyor.

G.A.S.—George Alfred Stonier, formerly Field Assistant, now Geological Surveyor.

J.B.J.—John Blockley Jaquet, Geological Surveyor.

J.C.H.M.—John Charles Henderson Mingaye, Analyst and Assayer.

W.S.L.—Walter Smith Leigh, Superintendent of Caves.

P.T.H.—Percy Thomas Hammond, Field Assistant.

*From 1875 to 1890, under the title of Annual Report of the Department of Mines, New South Wales; since that date, Annual Report of the Department of Mines and Agriculture, New South Wales.

To these may be added:—

H.W.—Harrie Wood, J.P., Under Secretary for Mines and Agriculture.

H.B.S.—H. B. Sullivan, Chief Mining Surveyor.

W.H.J.S.—W. H. J. Slee, Chief Inspector of Mines and Superintendent of Drills.

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XXVIII.—On the occurrence of *Lepidodendron australe* (?) in the Devonian Rocks of New South Wales: by T. W. E. DAVID, B.A., Professor of Geology, Sydney University, and E. F. PITTMAN, A.R.S.M., Government Geologist.

[Plates XVII–XIX.]

Historical.

THE earliest recorded discovery of *Lepidodendron* in Australia, as far as we are aware, is that of Sir Thomas Mitchell,* who in 1835 found *Lepidodendron* at Wallamoul, Peel River, near Tamworth, and forwarded the specimen to Mr. W. Lonsdale, F.G.S., who identified and described it in 1853.

In 1848 the Rev. W. B. Clarke, F.R.S., recorded† the occurrence of *Lepidodendron* "from the shales of the Manilla River, and on the Namoi and Gwydir Rivers,

* Recent Geological Discoveries in Australasia. Rev. W. B. Clarke, read before the Philosophical Society of New South Wales, 20th November, 1861.

† On the Genera and Distribution of Plants in the Carboniferous System of New South Wales—*Quart. Journ. Geol. Soc.*, 1848, IV, p. 60. (Quoted by Mr. R. Etheridge, Junr. *Records Geol. Survey N. S. Wales*, II, Pt. 3, p. 120).

from the grits and sandstones of the Paterson River, and from the hard siliceous metamorphic rocks of Colocolo on the Allyn River, associated with Brachiopoda and Trilobites."

The Rev. W. B. Clarke states* that in June, 1851, Professor McCoy wrote to him from Cambridge respecting the first *Lepidodendron* he had seen from Australia, and which had been forwarded by Mr. Clarke in 1849 to Professor Sedgwick. Professor McCoy stated that this specimen was identical with *L. tetragonum* of the English coalfields. In November, 1863, (*loc. cit.*), Sir C. Bunbury, in a letter to Professor R. Jones, confirmed Professor McCoy's opinion considering the Australian fossil to be very like *L. tetragonum.*

In 1853, Mr. S. Stutchbury,† at that time Government Geological Surveyor, records having found at the crossing place of the Oakey Creek, four miles from Cobbadah, several specimens of *Lepidodendron* in argillaceous shales and sandstones. He also figures (*loc. cit.*) in outline, one of the specimens from that locality. It is probable, from the rectangular form of the leaf scars, that the specimen was specifically identical with the one forwarded to Sedgwick.

Subsequent discoveries of *Lepidodendron* in 1855 by Mr. F. Odernheimer, in the Peel River District, and in 1856 by Mr. J. S. Wilson, at Goonoo Creek, near Tamworth, are alluded to by Mr. R. Etheridge, Junr., in his paper previously quoted.‡

In 1861, Professor (now Sir Frederick) McCoy, F.R.S., described and named *Lepidodendron australe* from the rocks of the Avon River, Gippsland, Victoria. These rocks are classed by Mr. R. A. F. Murray, F.G.S., Government Geologist, as Upper Devonian, though he states that they are strongly uncomformable to the Middle Devonian rocks of Victoria, and therefore that§ "it is highly probable, judging from their stratigraphical position, that the Avon sandstones are—as indicated by Professor McCoy, on palæontological evidence—of Lower Carboniferous age, or passage beds in that direction upwards from the Upper Devonian beds."

In 1870 Mr. R. Daintree, F.G.S., who was then Government Geologist of Queensland, found specimens of *Lepidodendron* in that Colony, and those collected by him from Mt. Wyatt, Canoona, and the Broken River, were subsequently identified by Mr. W. Carruthers, F.R.S.,§ as *Leptophlæum rhombicum*, previously described by Dawson as occurring in the Upper Devonian Series of Canada. In Appendix II, Mr. Carruthers describes†† these Queensland plant fossils as *Lepidodendron nothum*, Unger, from which it appears that the two names were regarded as synonymous.

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* Sedimentary Form. N. S. Wales, Fourth Edition, 1878, p. 21.
† Geological Surveys, New South Wales. Letter to Colonial Secretary, dated 1st July, 1853 (published as a Parliamentary Paper), p 9.
‡ Records Geol. Survey, N.S.Wales, II, Pt. 3.
§ Geology and Physical Geography of Victoria, 1887, p. 67.
‖ Quart. Journ. Geol. Soc., 1872, XXVIII, p. 259.
†† *Loc. cit.* p. 358.

At Mt. Wyatt* the plant-beds are stated to be interstratified with strata containing *Spirifer*, &c.; no figures of those *Spiriferæ* appear however to have been published.

In 1874 Professor McCoy furnished a detailed description and plate of *Lepidodendron australe*.†

In 1875 Mr. C. S. Wilkinson, F.G.S., F.L.S., Government Geologist of New South Wales, published a geological map of the districts of Hartley, Bowenfels, Wallerawang, and Rydal, and recorded the occurrence, *in situ*, of *Lepidodendron* in altered sandstone beds near the last-named locality. The Rev. W. B. Clarke had previously discovered the fossil in these rocks.

In 1876 and 1877 Mr. Clarke found *Lepidodendron, in situ*, in this neighbourhood, and he states: "I was enabled to detect the plant actually *in situ* and which enabled me‡ to ascertain the proper position of its habitat, which is considerably below the level of the Brachiopod sandstone of Mt. Lambie, and on a spur of that range overlooking Solitary Creek. As a guide to future explorers I left a broad-arrow mark on the fence nearest the spot." During a recent visit to the locality we endeavoured to find this broad-arrow mark, but failed to do so. We were informed, however, by Mr. Francis Lord (of Mt. Lambie House), who had been in company with Mr. Clarke when the mark was made, that it was approximately in the position marked "A" on the accompanying sketch map.

In the year 1875 Mr. John Mackenzie, F.G.S., Examiner of Coal-fields, New South Wales, published§ some sections measured partly by himself showing the occurrence of *Lepidodendron* in the Stroud District. In cutting trenches to explore the Coal Measures in the property of the Australian Agricultural Company, he found *Lepidodendron* (*in situ*) in close association with *Productus*, *Spirifera*, &c.

In 1877 one of the Authors‖ found *Lepidodendron* at Copeland in the Gloucester District, and a number of specimens were afterwards obtained *in situ* by the collector, Mr. Charles Cullen. The geological horizon from which these specimens were obtained is probably Carboniferous.

Dr. Ottokar Feistmantel, late Professor in the Bohemian Polytechnic University, Prague, formerly Palæontologist to the Geological Survey of India, in 1878 and 1879, published an account of five species of Australian *Lepidodendra* in a work¶ on the Palæozoic and Mesozoic Flora of Eastern Australia. His descriptions and

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* *Loc. cit.* p. 289.
† Prod. Pal. Vict., 1874, Dec. I., p. 37.
‡ Sedimentary Form. N.S.Wales, Fourth Edition, 1878, p. 22.
§ Mines and Mineral Statistics of New South Wales, Sydney, 1875.
‖ Report on the Barrington Gold-field, by E. F. Pittman, A.R.S.M. *Ann. Report Dept. Mines N.S. Wales*, 1877, p. 10.
¶ Palæozoische und Mesozoische Flora des östlichen Australiens. *Palæontographica, Suppl. Bd.* III, *Lief.* 3, *Heft* 2, 3, 4 (Cassel, 1878 und 1879).

figures were based upon two collections of Australian fossil plants forwarded to him by the Rev. W. B. Clarke, in 1876 and 1878. These specimens Dr. Feismantel referred to the following species:—

Lepidodendron australe, McCoy, from Avon River, Gippsland, Victoria.

L. nothum, Unger, Mount Wyatt, Canoona, and Broken River, Northern Queensland, Drummond Range, Queensland. In New South Wales, Cowra, Canowindra, Goonoo Goonoo Creek, Back Creek Diggings, and on the Barrington River.

L. (*comp.*) *dichotomum*, Sternberg, Smith's Creek, Stroud, and Rouchel River, in New South Wales.

L. veltheimianum, Sternberg, Rouchel River, "with abundance of Lower Carboniferous marine forms" (*fide* Rev. W. B. Clarke), and at Smith's Creek, Stroud, in New South Wales, Bogantungan (*fide* Rev. J. E. Tenison-Woods, F.G.S.), Drummond Range, Queensland.

L. volkmannianum, Sternberg, Smith's Creek, Stroud, New South Wales.

The Rev. W. B. Clarke states* that:—"Professor De Koninck also found imbedded with the marine fossils of my collection from the Lower Carboniferous of Muree, Glen William, Burragood, and the Karuah various well-known plants, such as *L. Veltheimianum* (Sternb.)," etc.

This collection was probably forwarded to Professor De Koninck in 1875 or 1876.

In 1889, Mr. Robert Kidston, F.G.S., of Stirling, N.B., described† two specimens of *Lepidodendron* collected by Mr. D. A. Porter of Tamworth, as *Lepidodendron volkmannianum*. Both specimens were in the form of casts, and were considered by Mr. Kidston to be much distorted representatives of *Lepidodendron volkmannianum*, the leaf-scars of which have flat boundary lines with a rounded upper margin. *L. volkmannianum* is restricted to the Culm of the Germans and the Calciferous Series of Scotland. Mr. Kidston considered that the horizon from which the specimens of *Lepidodendron* forwarded to him were collected was probably rather Lower Carboniferous than Upper Devonian.

In the year 1891, Mr. Robt. Etheridge, Junr., contributed an exhaustive paper on the subject of *Lepidodendron australe*.‡ After ably reviewing the distinctive characteristics of *L. nothum*, Unger, and *L. australe*, M'Coy, he records his opinion that the specimens described by Mr. Carruthers from Queensland, are not *L. nothum*, but are specifically identical with *L. australe*, McCoy. Mr. Etheridge further expressed the opinion that the species *L. nothum* had not yet been conclusively proved to occur anywhere in Australia, and considered that all

* Sedimentary Form. N.S. Wales, Fourth Edition, 1878, p. 28.
† Records Geol. Survey N.S.Wales, I, Pt. 1, pp. 114-116.
‡ Records Geol. Survey N.S. Wales, II, Pt. 3, pp 119-134.

the localities from which *L. australe* had been obtained up to the date of his paper were probably Carboniferous or Lower Carboniferous, with the exception of Mt. Wyatt, in Queensland, and Mt. Lambie, in New South Wales, which might possibly be Devonian, though no absolute proof, he considered, had been supplied. Commenting upon the Rev. W. B. Clarke's statement* that the proper position of its *L. australe* habitat was considerably below the level of the Brachiopod Sandstone of Mount Lambie,† Mr. Etheridge concludes that Mr. Clarke did not intend this to mean stratigraphically below the Brachiopod Sandstone, but lower in altitude than that rock.

We are nevertheless of opinion that the expression should be interpreted to mean *stratigraphically below*, as the mere fact of one series of rocks being below another in altitude would in this case have no special significance; the real point at issue, as may be inferred from the context, being the stratigraphical sequence of the Lepidodendron beds and the Brachiopod Sandstone. If this interpretation be correct our recent examination of the locality shows that Mr. Clarke was probably mistaken as to the geological horizon whence his specimens were obtained, with reference to the Brachiopod Sandstone, as the strata marked by him as containing *Lepidodendron* are unquestionably higher in a stratigraphical sense than the Brachiopod Sandstones; and this is clearly and correctly shown in the section upon Mr. Wilkinson's geological map of the Hartley, Bowenfels, Wallerawang, and Rydal Districts.

In 1892, Mr. R. J. Jack, F.G.S., Government Geologist of Queensland, and Mr. R. Etheridge, Junr., in their work† on the 'Geology and Palæontology of Queensland and New Guinea,' describe and figure the following species of *Lepidodendron* from the undermentioned localities:—*L. australe*, McCoy; Corner, Sandy, Horse, and Donald's Creeks, Great Star River; road to Harvest Home two miles west of Mount M'Connell, Mount Wyatt, Canoona, Broken River; Medway River, Bogantungan, and Drummond Range (Star Beds); Training Wall Quarries, Rockhampton, with marine mollusca; Murphy's Tunnel, Pioneer Hill, Hodgkinson Gold Field (Gympie Beds).

L. veltheimianum, Sternberg, Drummond Range; and Bogantungan, Drummond Range. (Star Beds.)

In January, 1892, Mr. W. J. Clunies Ross, B. Sc., F.G.S., contributed a paper "On the Occurrence of *Lepidodendron* near Bathurst,"‡ as a result of his geological observations in the field he shows that the marine Devonian beds are extensively developed near the Winburndale Creek, about from ten up to sixteen miles east of Bathurst. Near this locality he discovered a loose fragment of rock containing

* Sedimentary Forms. N. S. Wales, Fourth Edition, 1878, p 22.
† The Geology and Palæontology of Queensland and New Guinea. By R. L. Jack, F.G.S., F.R.G.S., and Robert Etheridge, Junr. Government Printer, Brisbane, 1892.
‡ Proc. Aust. Assoc. Adv. Sci., 1892, IV, pp. 332-337.

an impression of *L. australe*, occurring under such circumstances as led him to infer that it had probably been derived from a horizon stratigraphically below or identical with that of the Brachiopod Sandstone.

In July, 1892, Mr. P. T. Hammond, Assistant to Mr. Geological Surveyor W. Anderson discovered *Lepidodendron australe* in association with marine fossils, in rocks which are probably of Upper Devonian age on a hill over-looking Back Creek, about three miles from Major's Creek Township. A number of other specimens of *L. australe* (some of them *in situ*) were subsequently discovered in this locality by Mr. W. Anderson, and the Authors. The specimens are preserved as casts in ferruginous gritty sandstones, below which occur purple shales succeeded by marine grits and a basal conglomerate of quartz-felsite resting on an irregularly eroded surface of quartz-felsite.

With the object of collecting further evidence as to the relation of the Lepidodendron beds to the Brachiopod Sandstone of Mt. Lambie the Authors recently made two trips to the locality. During the first trip which took place about the middle of March of the present year, no specimens of *Lepidodendron* showing leaf scars could be discovered, but at the point (*j*) on the accompanying sketch map an obscure impression of a plant probably representing a *Lepidodendron* in a *Knorria* condition was found *in situ* in a bed of quartzite considerably below (stratigraphically) the *Spirifera disjuncta* Sandstones. On the same day in the bed of Solitary Creek at a spot marked (*e*) on the accompanying sketch map, several marine fossils not hitherto recorded as occurring in the Devonian rocks of this locality were collected. Amongst these may be mentioned an *Orthoceras*, and two others, which have been identified by Mr. Robt. Etheridge, Junr., as *Leptodomus* and *Pteronites*, the latter occurring in considerable numbers. These marine shells were associated with abundant casts of *Spirifera disjuncta* and *Rhynchonella pleurodon*. The second occasion on which we visited this district was on the 30th March when we were again unsuccessful in obtaining *Lepidodendron* but on the following day (31st March) we discovered about twenty specimens, *in situ*, at the spot marked (*b*) on the accompanying sketch map, and about half a mile in a southerly direction from where the Rev. W. B. Clarke cut a broad-arrow mark on the fence and from where Mr. Wilkinson obtained five specimens of *L. australe*, in 1875. We marked a tree on top of the ridge about seventy-five yards west of where the *Lepidodendron* occurred.

One of the specimens found by us at this spot is figured on the accompanying Pl. XVII, Fig. 2, and is undoubtedly *L. australe*.

On the afternoon of the same day we collected six specimens, *in situ*, at another locality on the road to Mt. Lambie. This spot is marked (*c*) on the accompanying sketch map and is about three quarters of a mile nearer to the Mount than the locality whence Messrs. Clarke and Wilkinson obtained their

Lepidodendra. Two of the specimens found at the spot marked (*c*) are figured in Pl. XVII, Figs. 1 and 3, respectively. The first is regarded by Mr. R. Etheridge, Junr., as probably a decorticated example of *Lepidodendron;* the second is evidently *L. australe.* Although the spot at which this discovery was made is about a mile nearer to Mt. Lambie than the site of the first discovery, and in a direction nearly at right angles to the strike of the beds, it is probable that the specimens from both places were on about the same geological horizon, as a synclinal trough intervenes, occasioning a repetition of the beds. This syncline is partially shown on the section accompanying Mr. Wilkinson's map, but is illustrated in greater detail on the sketch section accompanying this paper.

On the 1st April, we found at the point marked (*d*) on the accompanying sketch map a cylindrical cast of *Lepidodendron* in an angular fragment of rock containing marine fossils. This fragment measured about nine inches by six, and consisted of gritty sandstone with small angular pieces of clay slate. From the appearance of the fragment there is no doubt that it had not travelled many hundred yards, and must have been derived from a horizon several hundred feet stratigraphically below the uppermost stratum of sandstone containing *Spirifera disjuncta.* This specimen although in an imperfect state of preservation, shows traces of leaf scars sufficiently distinct to warrant its being classed as some form of *Lepidodendron,* probably *L. australe.* It has been well reproduced in the accompanying plate by Mr. P. T. Hammond, Pl. XVII, Fig. 4. Two of the casts of marine fossils with which it is associated are also shown in the plate, Pl. XVII, Figs. 5 and 6. Imperfect casts of a number of small shells, probably *Rhynchonella* were also present in the fragment. Inasmuch as no marine fossils are known to occur in this series above the *Spirifera disjuncta* beds, this Brachiopod ranges to the top of the Marine Upper Devonian Series in this locality. The association of marine fossils with this specimen of *Lepidodendron* conclusively proves that its horizon must have been stratigraphically below the top of the marine Upper Devonian, and, therefore, there cannot in our opinion be any doubt as to the occurrence of *Lepidodendron* in Upper Devonian rocks.

The only alternative interpretation of the facts recorded would be that *Spirifera disjuncta* in Australia may possibly extend upwards into Lower Carboniferous rocks. On our return to Sydney we received communications from Mr. Clunies Ross, announcing that he also, on the 31st of March, had discovered a somewhat indistinct cast of *Lepidodendron australe,* associated with *Spirifera disjuncta,* in a large mass of rock practically *in situ.* The site of this discovery was about sixteen miles easterly from Bathurst.

A strong unconformability is observable at the junction line of the Permo-Carboniferous Upper Marine conglomerates in the neighbourhood of Rydal, with the *Spirifera disjuncta* and Lepidodendron beds, as is well shown on the section accompanying Mr. Wilkinson's map.

Interstratified with the whitish quartzites and sandstones of the Marine Devonian, and the clay shales of the Lepidodendron beds, are thick strata of reddish purple shale, analogous to the smaller beds recorded above at Back Creek, near Major's Creek township and similar (as far as can be judged from the description) to the purple shales associated with sheets of melaphyre in the Devonian rocks of the Avon River, Victoria.*

Conclusion:—In our opinion *L. veltheimianum*, *L. volkmannianum*, and *L. dichotomum*, in the present state of our knowledge of the stratigraphy of Eastern Australia, are referable to a Carboniferous or Lower Carboniferous horizon.

If we adopt the decisions of Sir Frederick McCoy, Messrs. R. Etheridge, Junr., and R. Kidston, viz., that the Australian specimens of *Lepidodendron* referred to *L. nothum* Unger, by Mr. Carruthers are identical with *L. australe*, the species *L. nothum* may be eliminated from the list of Australian fossils. The fact, however, must not be overlooked that Mr. R. Kidston considers it possible that some of the specimens of *Lepidodendron* from Australia described by Mr. Carruthers as *L. nothum* may be more nearly related to *Leptophlæum rhombicum*, Dawson, than to *L. australe*, McCoy.

In some parts of Australia *L. australe* is certainly found in rocks of Carboniferous or Lower Carboniferous age, and in view of the recent discoveries by Mr. Clunies Ross and ourselves, there can be no doubt that a *Lepidodendron*, probably *L. australe* occurs in *Spirifera disjuncta* beds near Mount Lambie; and if these beds are not Upper Devonian, it must be admitted that in Australia *Spirifera disjuncta* has a higher range than has been proved for this species in the northern hemisphere.

The discoveries of Mr. P. T. Hammond and Mr. William Anderson are likely to confirm our contention that in some parts of New South Wales *L. australe* is probably of Upper Devonian age.

XXIX.—On Celestine from the Neighbourhood of Bourke: by GEORGE W. CARD, A.R.S.M., Curator and Mineralogist.

IN turning over a number of miscellaneous specimens in the Museum Collections two nodules were found whose weight and general appearance suggested the desirability of a closer examination. This has been done with the result that they prove to be composed of Celestine, the sulphate of strontia. Both pieces were labelled "Bourke." Every effort has been made to trace the history of the

* R. A. F. Murray, Geology and Physical Geography of Victoria, pp. 66-67.

specimens and the exact locality from whence they came; but with indifferent success. They appear to have been received from the Bourke District not more than two years ago.

Together the pieces weighed about twelve ounces. The specific gravity, as determined by two of the Assistants, Messrs. G. Allen and L. F. Harper, by the Joly Balance, is 3·73*, the relatively high density of the stone being very noticeable when held in the hand. Close inspection shows that the mass is made up of a number of small crystals—not exceeding two millimetres in length. So far as they can be made out the crystals appear to be the simple tabular forms characteristic of celestine, but it is difficult to make the faces out distinctly. The more perfect faces have a vitreous lustre, and are sometimes notched or otherwise marked with angular depressions. The streak is quite colourless as is also the mineral itself, except where superficially reddened.

The softness of the mineral as a whole is such as to suggest gypsum, were it not for its high density, it being readily scratched with the thumb-nail. Even the crystal faces do not seem to quite attain the hardness usual to celestine (3-3·5).

Before the blow-pipe the reactions for strontium, and for a sulphate, are readily obtained, the flame-colouration being very pronounced.

The ultimate analysis of the mineral, for which I am indebted to Mr. J. C. H. Mingaye, is as follows:—

Moisture	·70
Sulphate of Strontia ($SrSO_4$)	93·57
Sulphate of Lime ($CaSO_4$)	·99
Sulphate of Baryta ($BaSO_4$)	trace
Silica (SiO_2)	3·22
Oxide of Iron and trace of Alumina	1·52
Magnesia (MgO)	·33
Chloride of Sodium (NaCl)	trace
	100·33

From the general appearance of the substance it seems probable that it occurs as nodules in the gypsum deposits.

As this is the first recorded instance of a strontium mineral from this Colony, a few remarks as to the occurrence and uses of strontium compounds as may be out of place.

Two strontia minerals are known,—the sulphate, celestine, and the carbonate strontianite.

* Pure celestine has a Sp. Gr. of 3·9.

Celestine occurs in considerable quantity in the Triassic marls of Gloucestershire, England. In 1891 the output from this district amounted to 8,061 tons of a value of £4,030 at the mines, while in 1892 these figures were 5,066 and 1,266 respectively. The output appears to be steadily decreasing. This mineral is also associated with the sulphur deposits of Girghenti, Sicily, which are of volcanic origin. As much of the gypsum from the western districts appears to be a deposit from the mud-springs, it may be that the celestine which forms the subject of this note may prove to have an origin analogous to that of the Sicilian mineral.

Strontianite was first described from a district in Argyleshire, Scotland, and occurs in small quantities as a secondary product in limestones and other rocks in many localities. Both minerals may be said to be of rare occurrence.

The application of strontium salts in the arts is a very limited one. Celestine is utilised in the manufacture of the nitrate of strontia, which is the basis of the red fire made use of in pyrotechnic displays. The process is a very simple one, consisting in the reduction of the sulphate to sulphide by heating with charcoal in a crucible, and neutralising the solution of the sulphide in water with nitric acid. Crystals of the nitrate are obtained on evaporation.

It is stated* that the strontianite of Westphalia, which occurs in veins in the Cretaceous strata, is being used for the production of caustic strontia, which is of use in the refining of sugar.

Should it prove possible to obtain celestine economically, there seems to be no reason why it should not be used locally in the manufacture of fireworks.

The weight of celestine renders it possible to readily distinguish it from gypsum, while the crimson colour that it imparts to a flame, when moistened with hydrochloric acid—spirits of salt—is very distinct from the greenish flame obtained from barytes, which is also characterised by its density, when similarly treated.

* Bauerman, Descriptive Mineralogy, 1884, p. 360.

PLATE XVI.

Palorchestes azael, *Owen*.

Fig. 1. Right upper molar series, showing pm^4 and m^{1-3}.

Fig. 2. Specimen of palatal region, with pm^4 and m^{1-3} on each side. x $\frac{1}{2}$.

Fig. 3. Left upper molar series, viewed from without.

Fig. 4. Inner view of left pm^4 showing portion of inner root.

Fig. 5. Portion of left maxillary showing the relative form of the roots of left pm^4.

Drawn from nature by Mr. G. H. Barrow, and with the exception of Fig. 2, all are of the natural size.

PLATE I.

Sketch plan of the Belubula Caves, by the late Mr. C. S. Wilkinson, Parish of Malongulli, Co. Bathurst.

A. Surface hole whence issues air from the cave below.

B. Large cavern about eighty feet below surface of hill.

C. "The Twins," remarkable stalagmites.

D. "Fountain Cave," containing water.

E. Circular hole in roof of the cavern.

F. Cave blocked up with masses of rock and earth.

H. Surface hole, whence issues a current of air from below.

K. Cavern, thirty-five feet high, conaining some very fine stalagmites and stalactites.

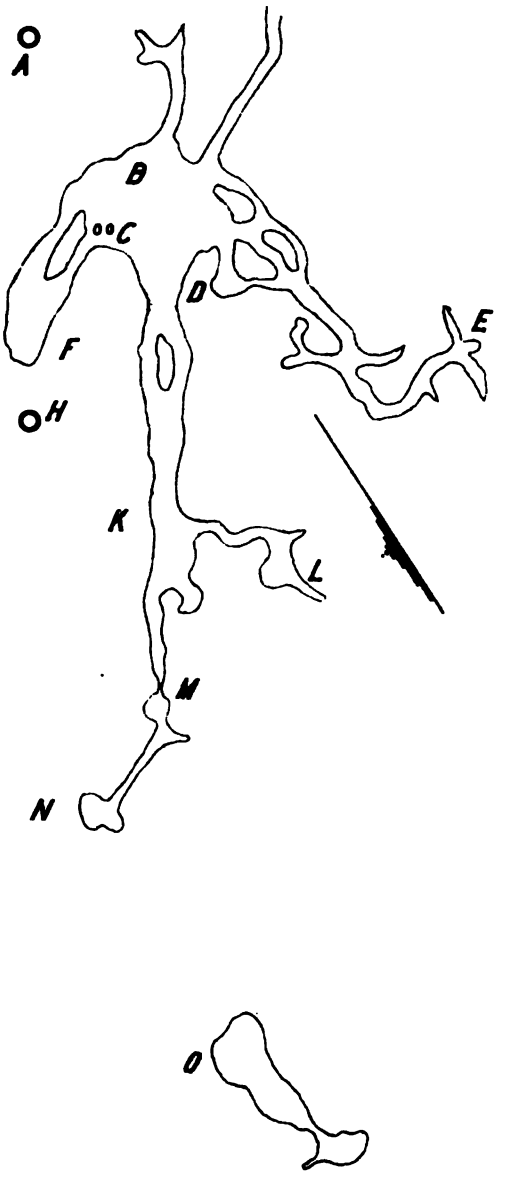
L. Thick deposit of red earth with bones.

M. Narrow passage.

N. Entrance to "Long Cave."

O. Entrance to "Bone Cave."

[Reproduced from an illustration in the Sydney *Town and Country Journal*, September 9, 1876.]



(11a/41-92)

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
SYDNEY, NEW SOUTH WALES.

PLATE II.

Stalactites overhanging two stalagmites, six feet high, Belubula Caves, Parish of Malongulli, Co. Bathurst.

[Reproduced from an illustration in the Sydney *Town and Country Journal*, September 9, 1876.]

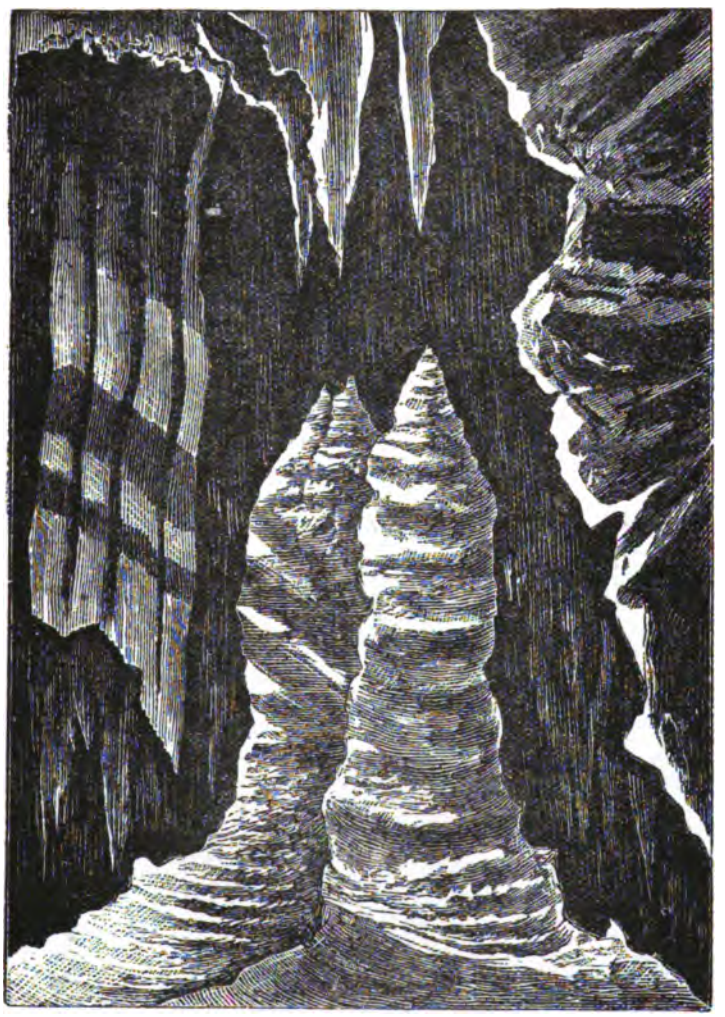


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PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
SYDNEY, NEW SOUTH WALES.

PLATE III.

Interior of Bone Cave, Belubula Caves, Parish of Malongulli, Co. Bathurst.

[Reproduced from an illustration in the Sydney *Town and Country Journal*, September 9, 1876.]

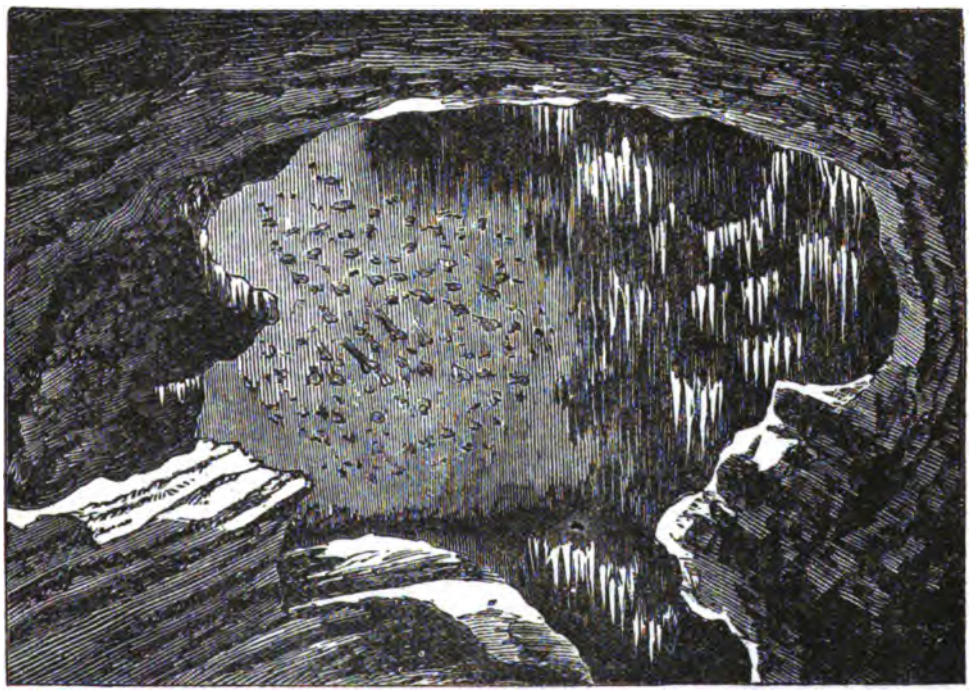

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PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
SYDNEY, NEW SOUTH WALES.

PLATE IV.

LINGULOCARIS M'COYII, *Eth. fil.*

Fig. 1. Carapace, showing double ventral edge and transversely-wrinkled surface.

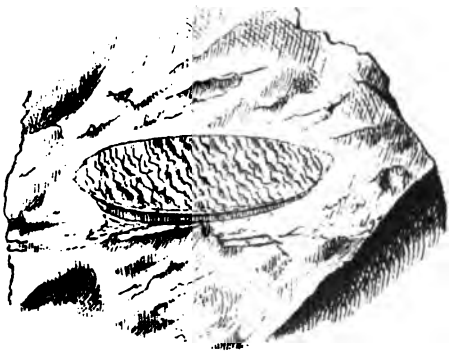
Fig. 2. Carapace with a longitudinally-wrinkled surface.

Fig. 3. Carapace with double ventral edge and almost smooth surface.

Fig. 4. Carapace, transversely-wrinkled, and a body lying at one end which may be an appendage.

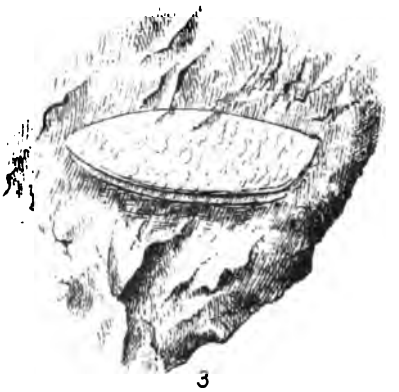
Drawn from nature by Mr. G. H. Barrow, Australian Museum.

2



1

4



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(11a/91-02.)

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
SYDNEY, NEW SOUTH WALES.

PLATE V.

Plan showing the Kybean Limestone on Great Limestone Creek, and surrounding rocks.

Scale about 10 chains = 1 inch.

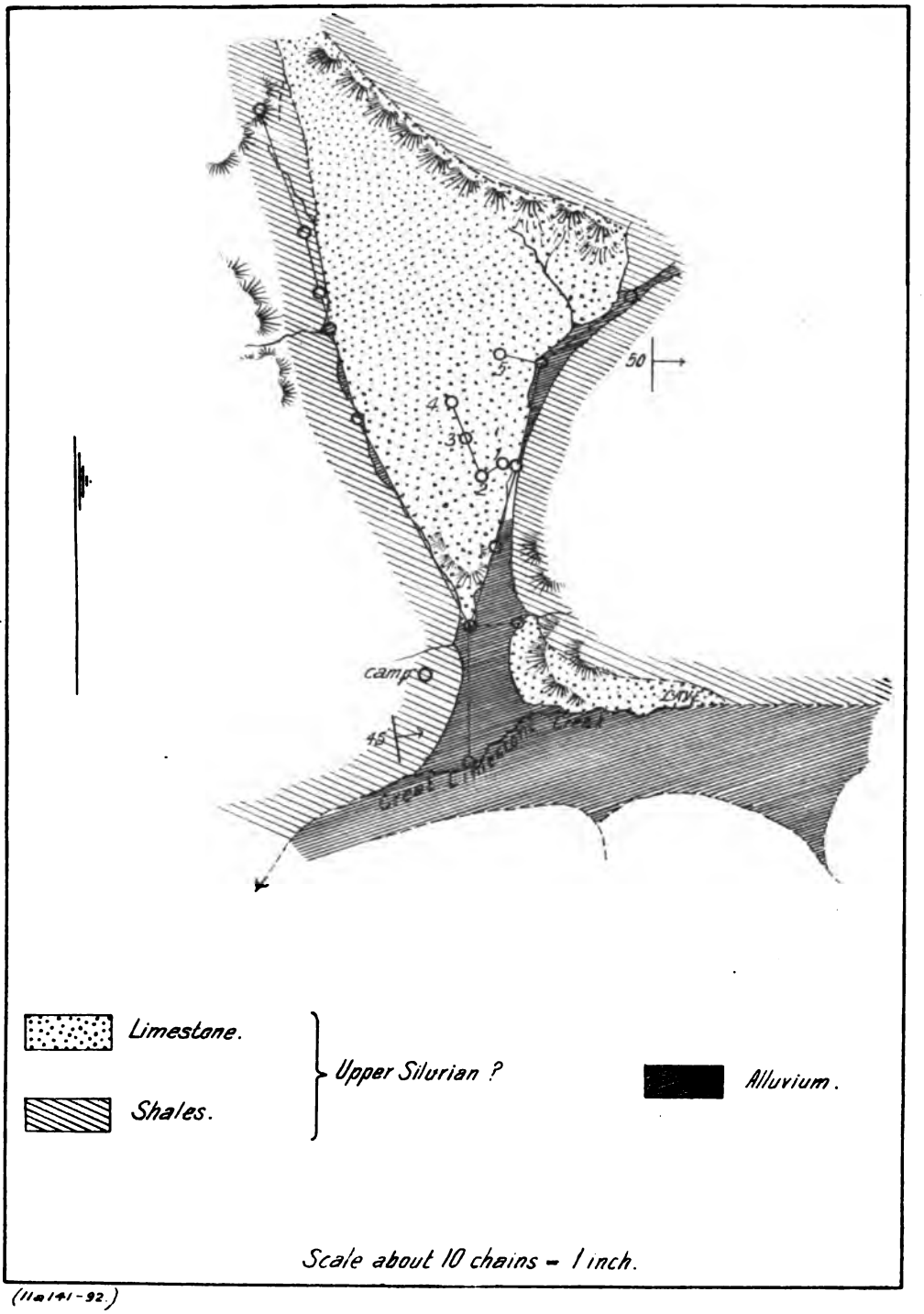

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PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

PLATE VI.

Sceparnodon Ramsayi, *Owen.* (Phascolonus gigas, *Owen.*)

Fig. 1. Left upper incisor of Owen and Lydekker; Tooth, showing pit caused by abrasion.

Fig. 2. Right upper incisor of Owen and Lydekker.

Fig. 3. Left upper incisor of Owen and Lydekker, very much worn.

Fig. 4. Blunt cutting edge of ditto.

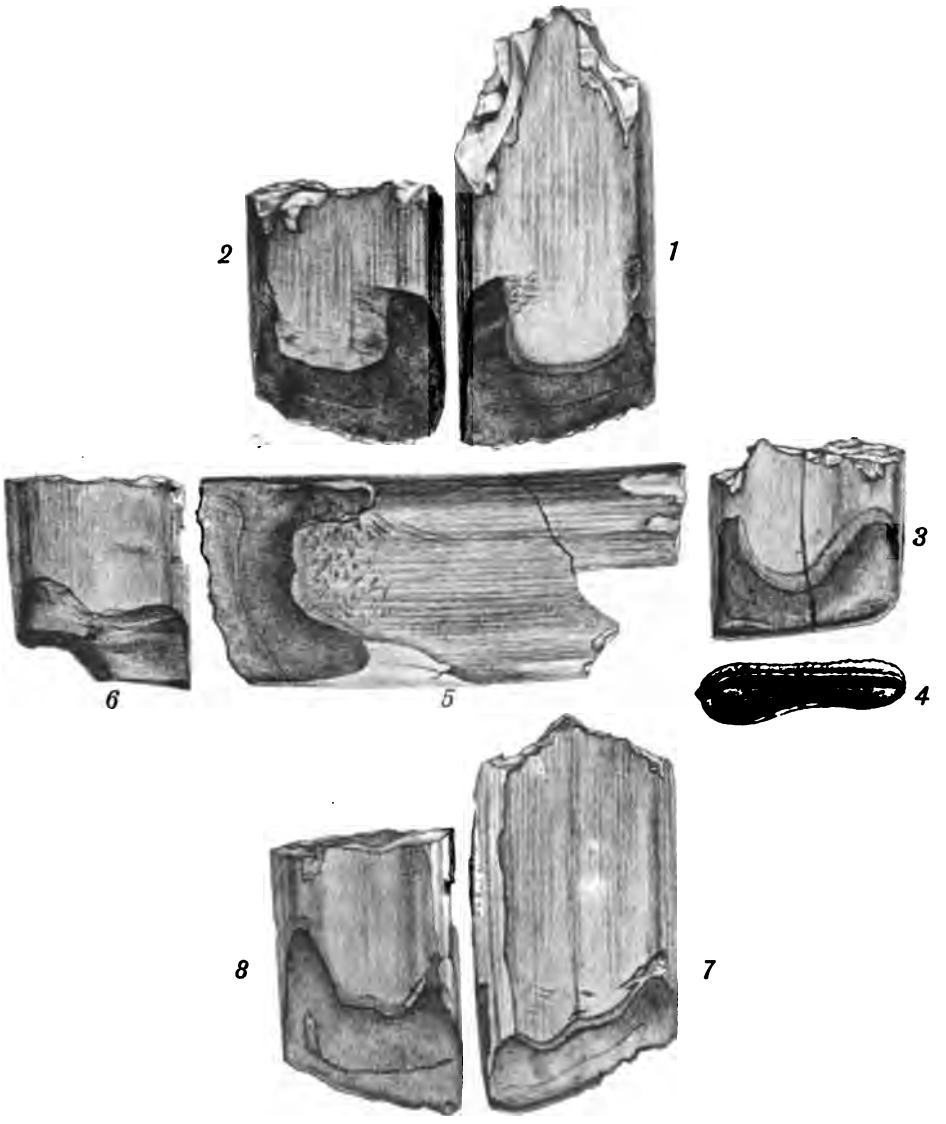
Fig. 5. Left upper incisor of Owen and Lydekker showing extensive bevelling and marks of abrasion on interior.

Fig. 6. Right upper incisor of Owen and Lydekker, of which the external corner has been broken during life; outer edge worn by contact with the corresponding lower incisor.

Fig. 7. Left upper incisor of Owen and Lydekker, showing a well marked median ridge, but no great amount of bevelling as in De Vis' lower incisor.

Fig. 8. Right ditto, ditto.

The figures drawn from nature by Mr. P. T. Hammond, are nearly three-fifths the natural size, and reversed.

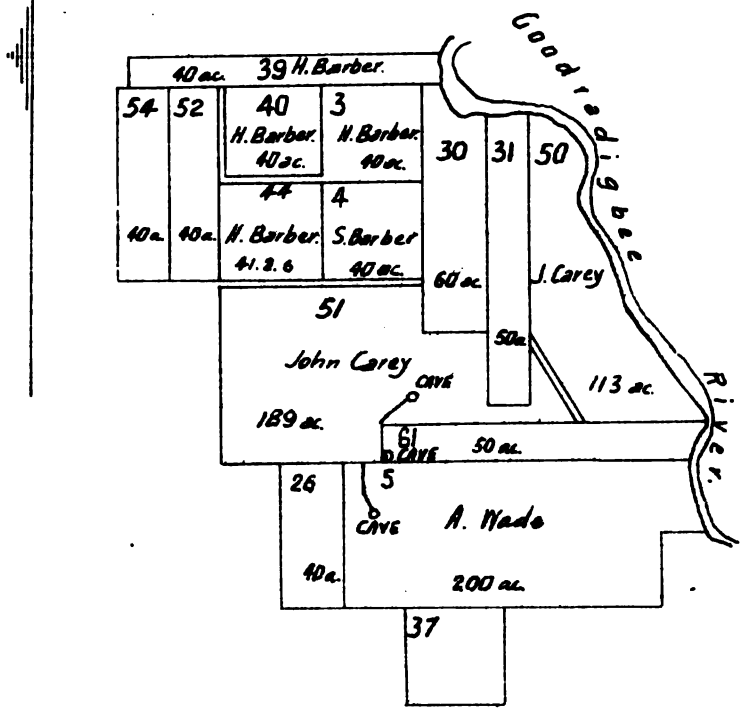


Reproduced by Heliotype.

PLATE VII.

Plan showing part of the Parish of West Goodradigbee, Co. Buccleuch, and relative positions of the Goodravale Caves.

Scales 40 chains = 1 inch.


40 ac.
39 H. Barber.
54
52
40
H. Barber.
40 ac.
3
H. Barber.
40 ac.
30
31
50
Coodradigbee
44
4
40 a.
40 a.
H. Barber.
41. 2. 6
S. Barber
40 ac.
60 ac.
J. Carey
51
50a.
John Carey
CAVE
113 ac.
River.
189 ac.
61
CAVE
50 ac.
26
5
CAVE
A. Wade
40 a.
200 ac.
37

(112141-92)

PLATE VIII.

Sketch plan of the Godradigbee Cave, Godravale, Godradigbee River, Parish of West Godradigbee, Co. Buccleuch.

Scale about 30 feet = 1 inch.

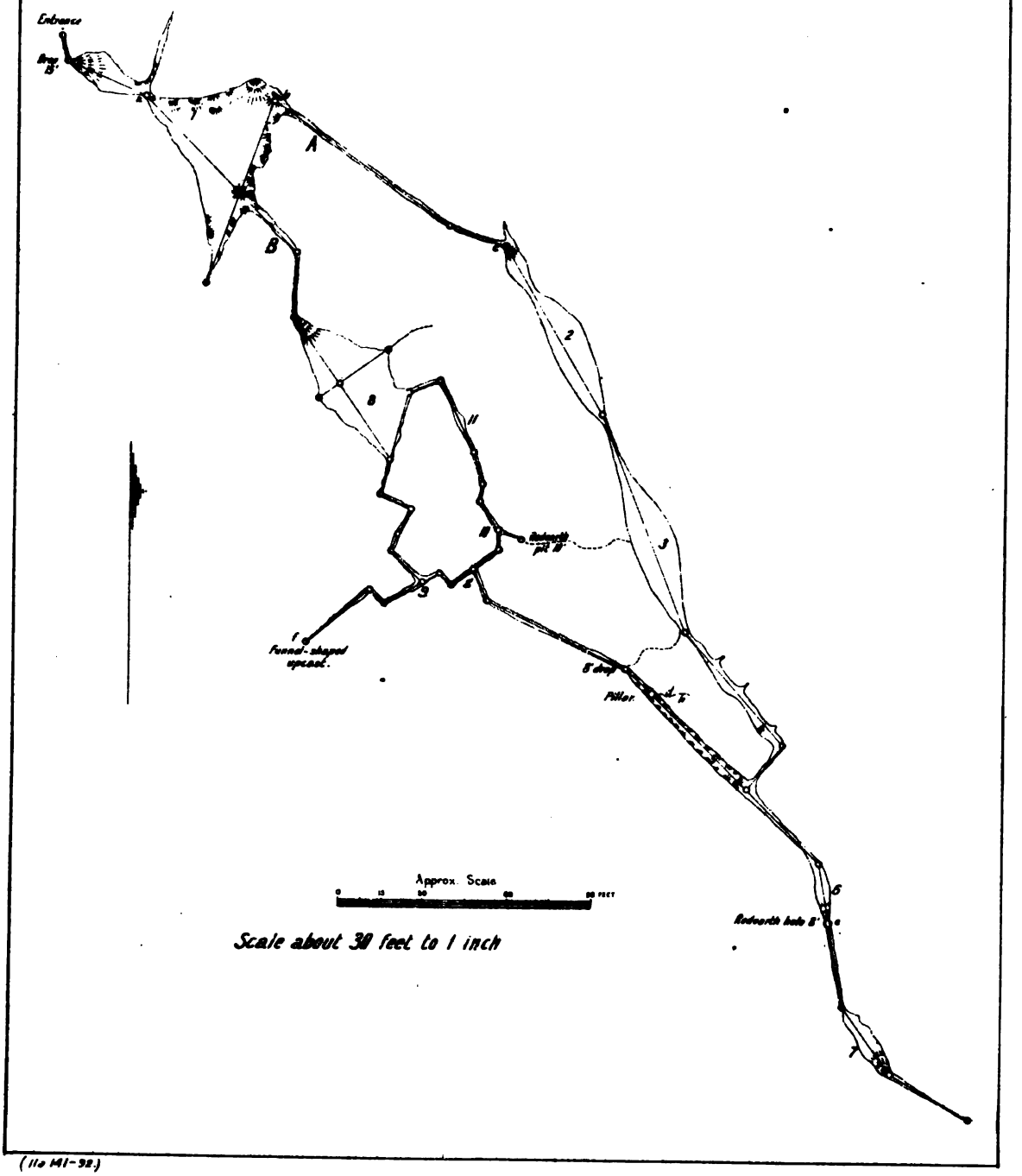


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PLATE IX.

Sketch plan of the Goodravale Cave, Goodravale, Goodradigbee River, Parish of West Godradigbee, Co. Buccleuch.

Scale about 30 feet 1 inch.

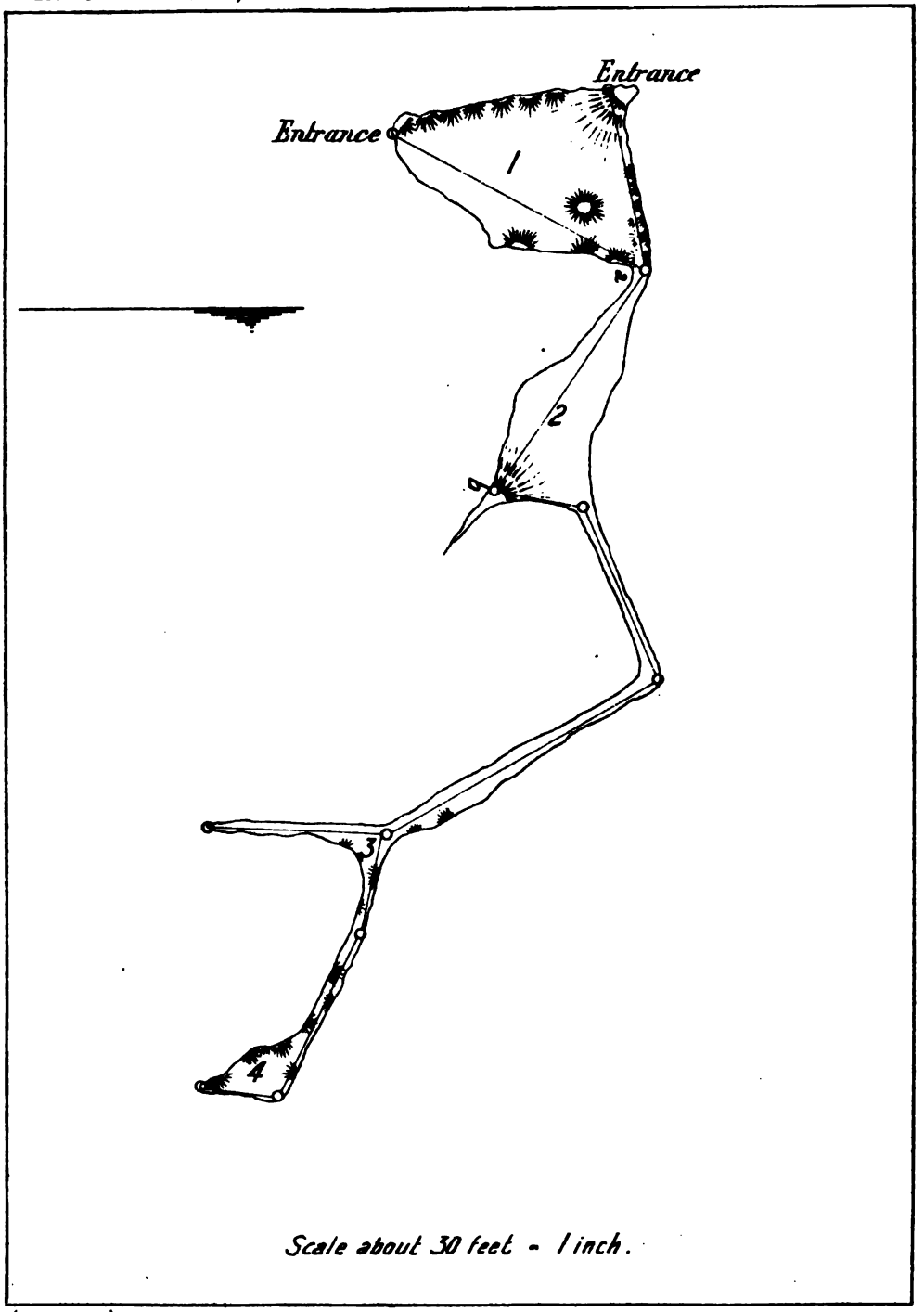

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PLATE X.

Pentamerus Knightii, *J. Sowerby.*

Fig. 1. Natural section of the ventral valve along the septum, showing the latter and one of the dental plates. Yarrangobilly Caves.

Fig. 2. Exterior of the same half, with coarse well separated costæ.

Fig. 3. The united halves, with the expanded front of the shell, and the long septum extending quite to the latter.

Fig. 4. Another specimen with the valves in apposition, the flanks more or less devoid of costæ, &c. Kerr's Creek.

Fig. 5. Side view of a young specimen showing flattened and indistinct costæ. Quedong.

Fig. 6. Another young individual in which the umbo is excentrically curved, and the costæ better defined. Forest Reefs.

Pentamerus? costatus, *Eth. fil.*

Fig. 7. Exterior of the ventral valve with the few coarse costæ, and narrow sulcus. Goodravale.

Fig. 8. The same specimen—with its channeled umbo and open fissure.

Drawn from nature by Mr. G. H. Barrow, Australian Museum.

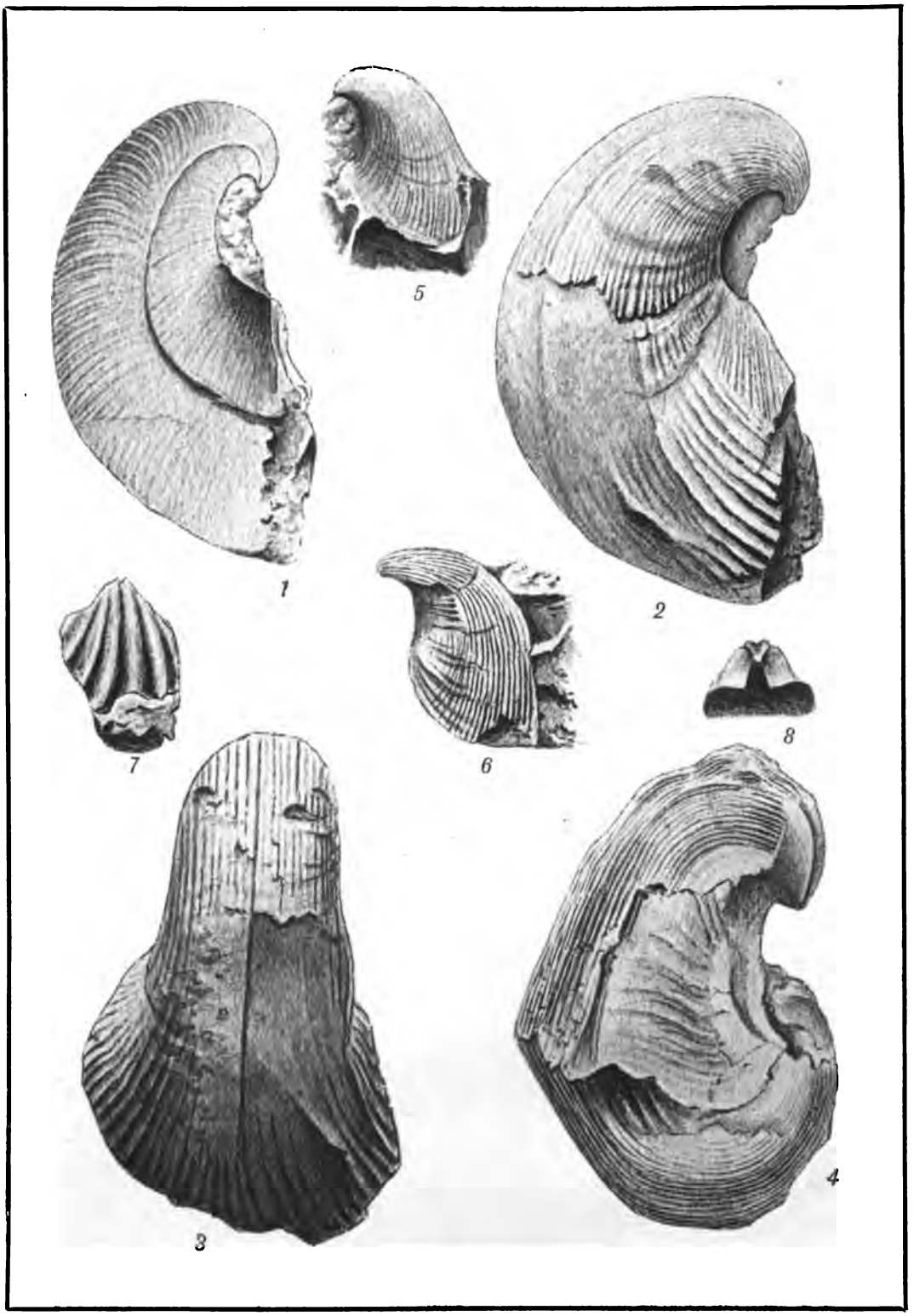

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PLATE XI.

Pentamerus Knightii, *J. Sowerby*.

Fig. 1. Front view of a specimen to show expansion of shell, and coarse costæ. Quedong.

Fig. 2. Natural section of the moiety of half a ventral valve, with the umbo highly incurved. Yarrangobilly.

Fig. 3. Front view of another ventral vale to show a slight] tendency towards a sulcus. Quedong.

Fig. 4. Natural weathered section of a ventral valve with the long septum, dental plates, and narrow V-shaped chamber. Walli.

Pentamerus linguifer, *var.* Wilkinsoni, *Eth. fil.*

Fig. 5. Dorsal view of valves in apposition illustrating the peculiar fold. The specimen is slightly distorted. Bowning District.

Fig. 6. Ventral view of the same to show the wide plain sulcus.

Fig. 7. Dorsal view of another specimen, showing the highly incurved and depressed umbo. Hatton's Corner.

Fig. 8. A young form. Bowning District.

Fig. 9. Internal cast of ventral valve, showing vascular system. Hatton's Corner

Pentamerus? costatus, *Eth. fil.*

Fig. 10. A weathered section of the ventral valve, with the septum and dental plates vertically cut. Goodravale.

Pentamerus hospes, *Barrande.*

Fig. 11. Decorticated ventral valve, with cast of the septum. Bowning District.

Fig. 12. Internal cast of a dorsal valve of a more triangular shape. x ½. Bowning District.

Drawn from nature by Mr. G. H. Barrow, Australian Museum.

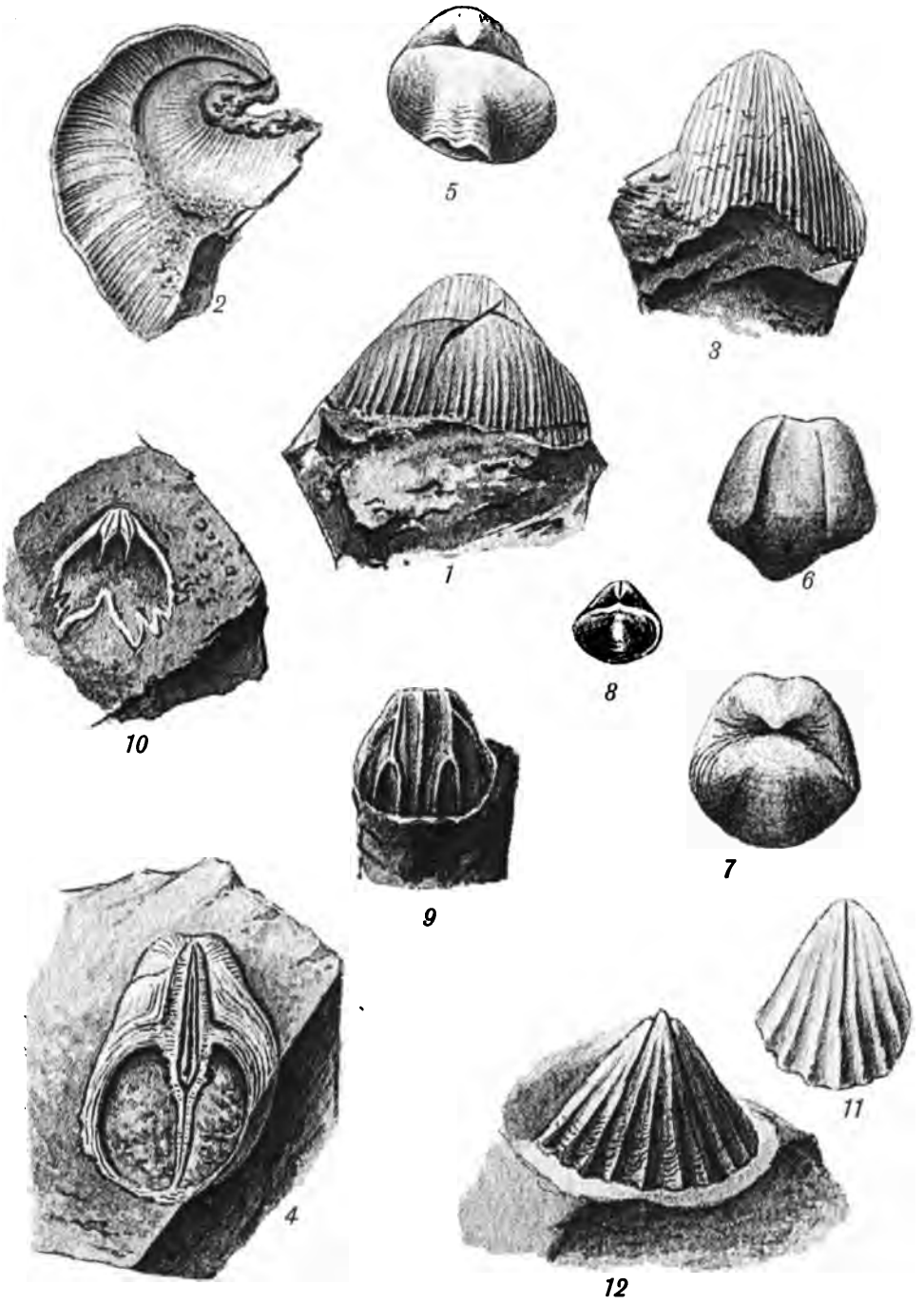

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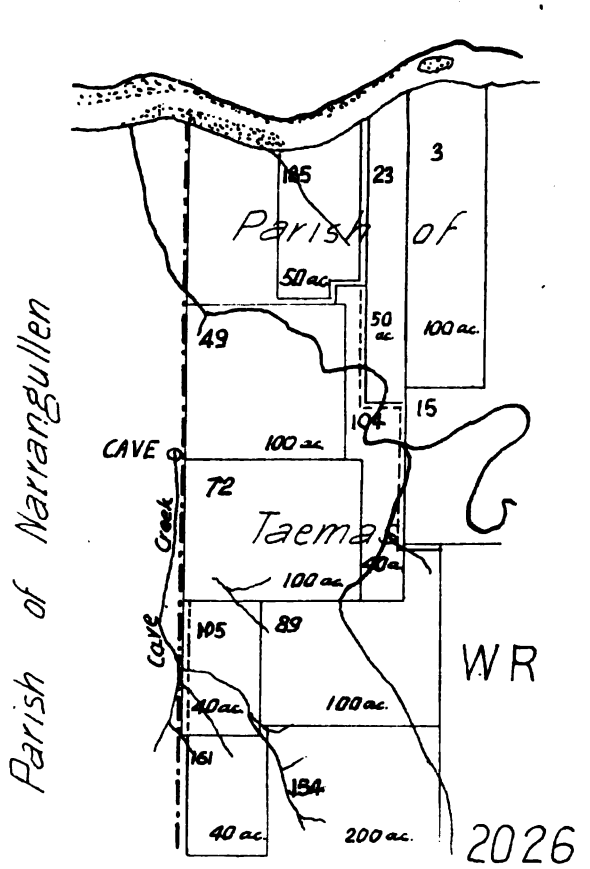
PLATE XII.

Plan of part of the Parishes of Taemas and Narrangullen, County of Cowley, showing the position of the Narrangullen Cave.

Scale 40 chains to 1 inch.



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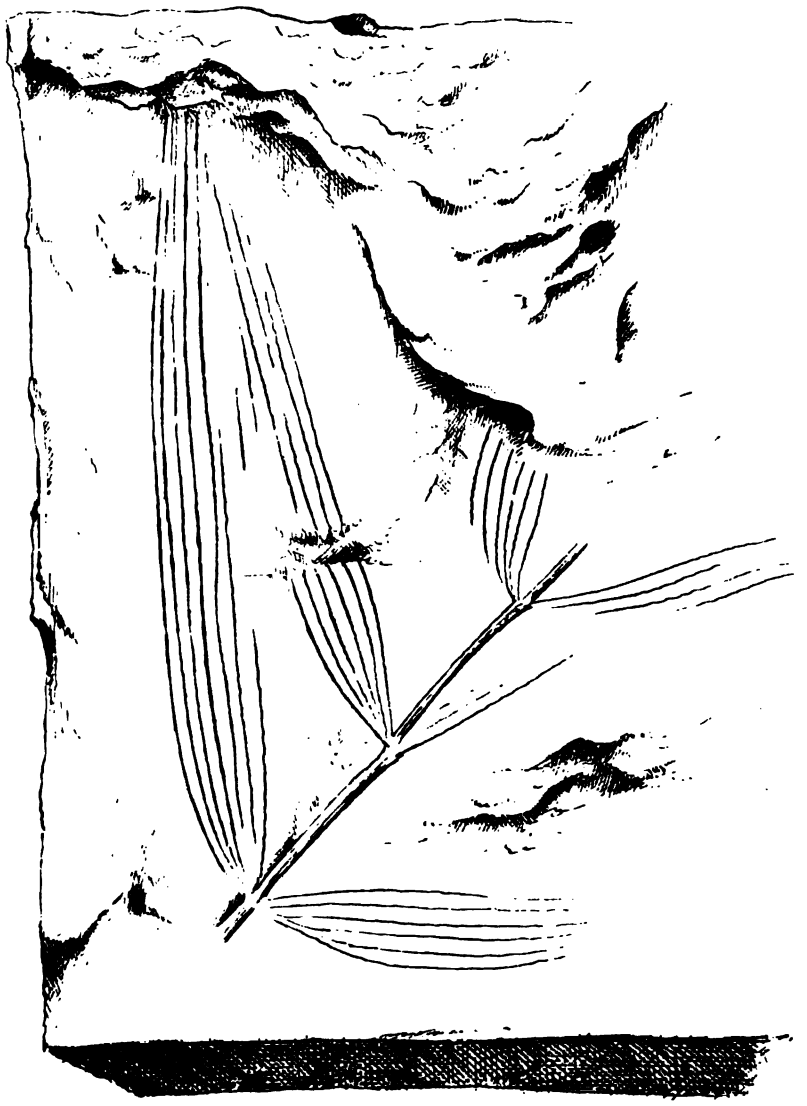

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PLATE XIV.

Plan of part of the Parish of Woolumla, County Beresford, showing the position of the Rosebrook Caves.

Scale, 40 chains to 1 inch.

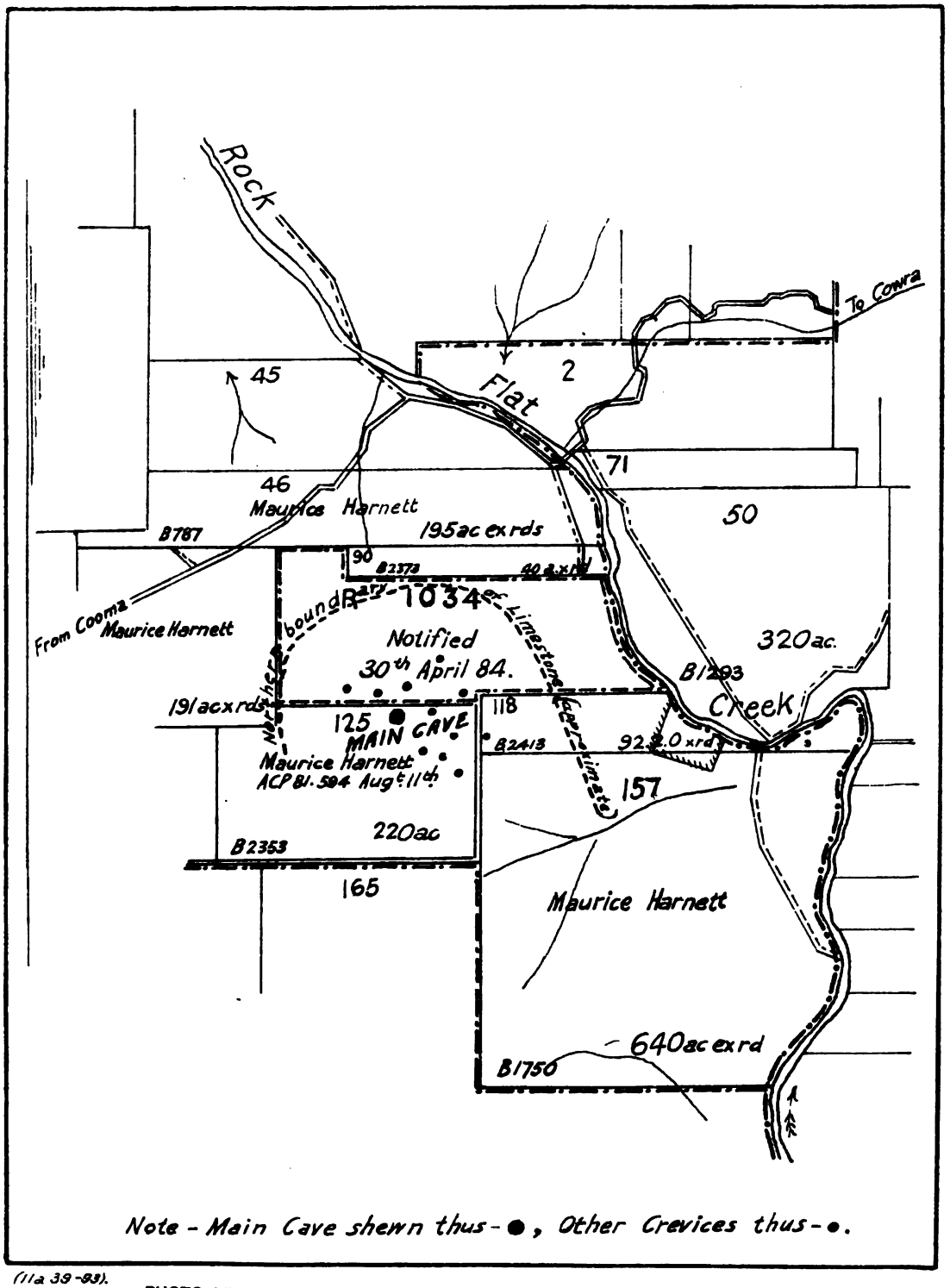

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PLATE XV.

Point Piper.

Fig. 1. Large fish, twenty-two feet long, and twelve and a half wide.

Figs. 2–5. Four subordinate small fish, each after a type of its own.

Fig. 6. Circle contiguous to two of the smaller fish.

Fig. 7. Shield with cross-bars and diamond-shaped ends; four and a half feet long.

Fig. 8. Kangaroo, ten feet high, with the hands and one eye well delineated.

Fig. 9. Kangaroo head, contiguous to Fig. 8.

Fig. 10. Fish, seven feet long.

Fig. 11. Male figure, with outstretched bent arms, and eyes, but no mouth.

Hawkesbury.

Fig. 12. Fish over twelve feet long.

Fig. 13. Male figure, with arms extended above the head, and a foot on the left leg.

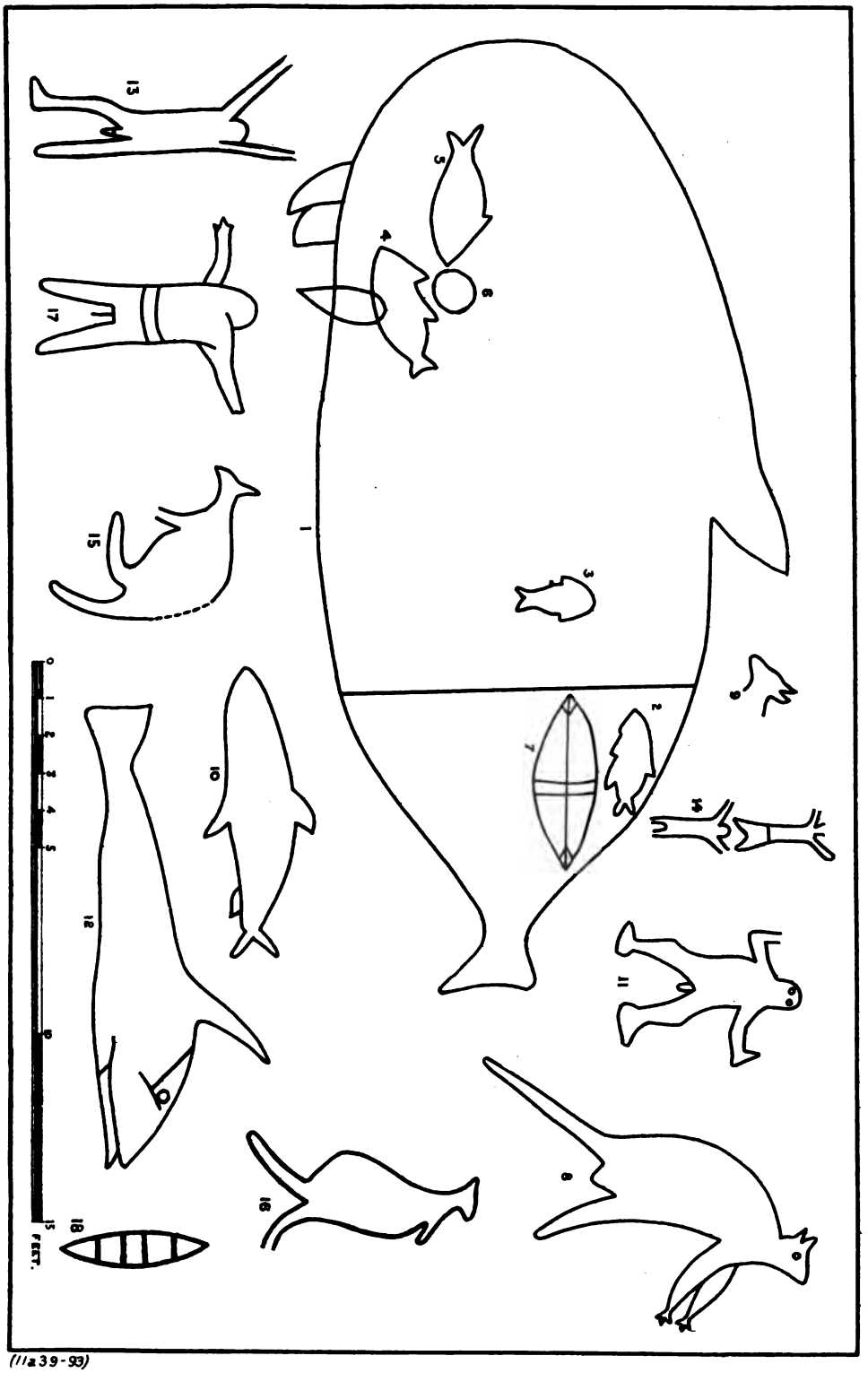
Fig. 14. Two diminutive male figures, supposed to represent boys, in one of the positions in which the initiates were placed during the *Bora*.

Fig. 15. Kangaroo, with the dorsal outline imperfect.

Fig. 16. Kangaroo, with badly executed head.

Fig. 17. Male figure, with the head pressed down on the shoulders, and clothed with the belt of manhood.

Fig. 18. Canoe, with four stretchers.



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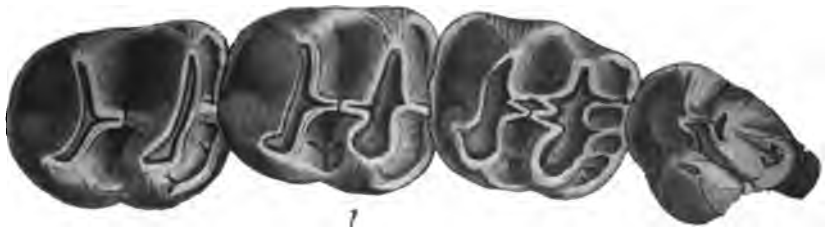

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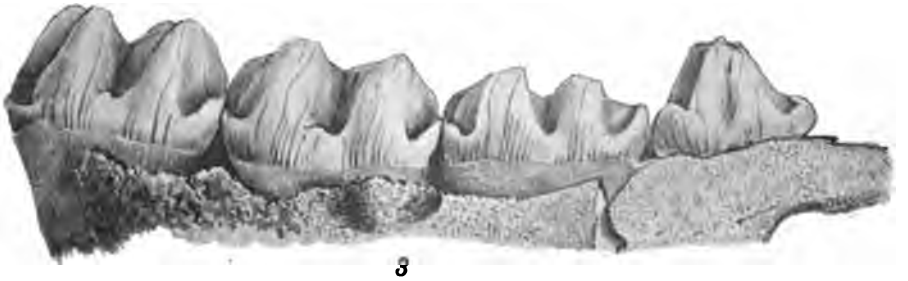

3

Heliotype.

PLATE XVII.

Lepidodendron australe, *McCoy*.

Fig. 1. Probably the decorticated or *Knorria* condition.

Fig. 2. Impression of part of a stem.

Fig. 3. Impression of part of a stem.

Fig. 4. Impression of the surface in the round.

Fig. 5 & 6. Undetermined shells.

Drawn from nature, of the natural size, by Mr. P. T. Hammond.

1

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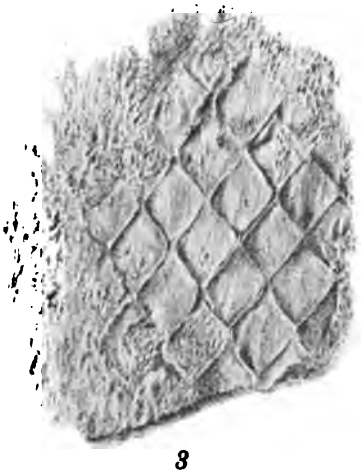

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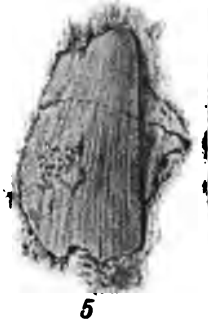

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PLATE XVIII.

Sketch Map (after the late Mr. C. S. Wilkinson) of the Mount Lambie District.

Scale, 40 chains = 1 inch.

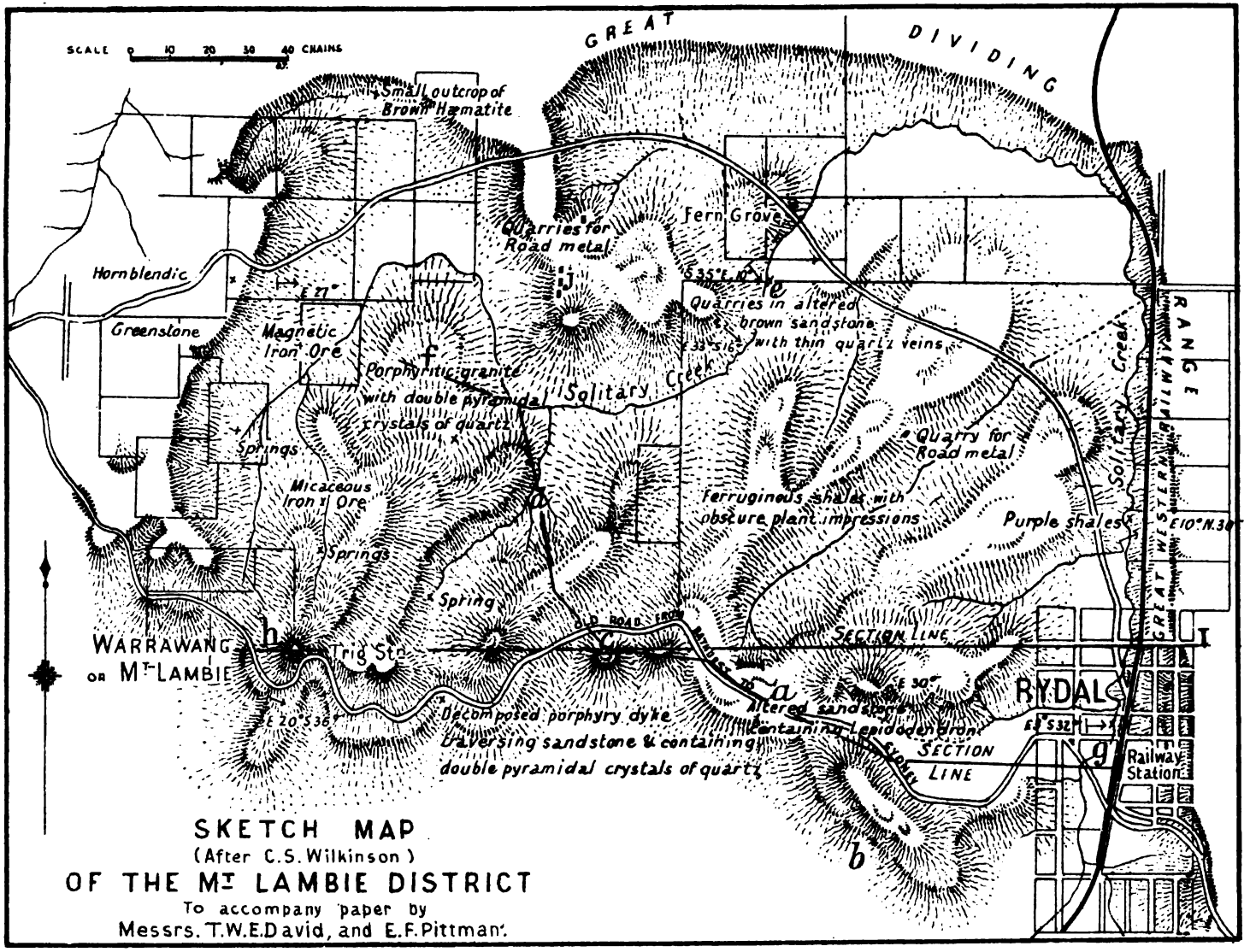

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PLATE XIX.

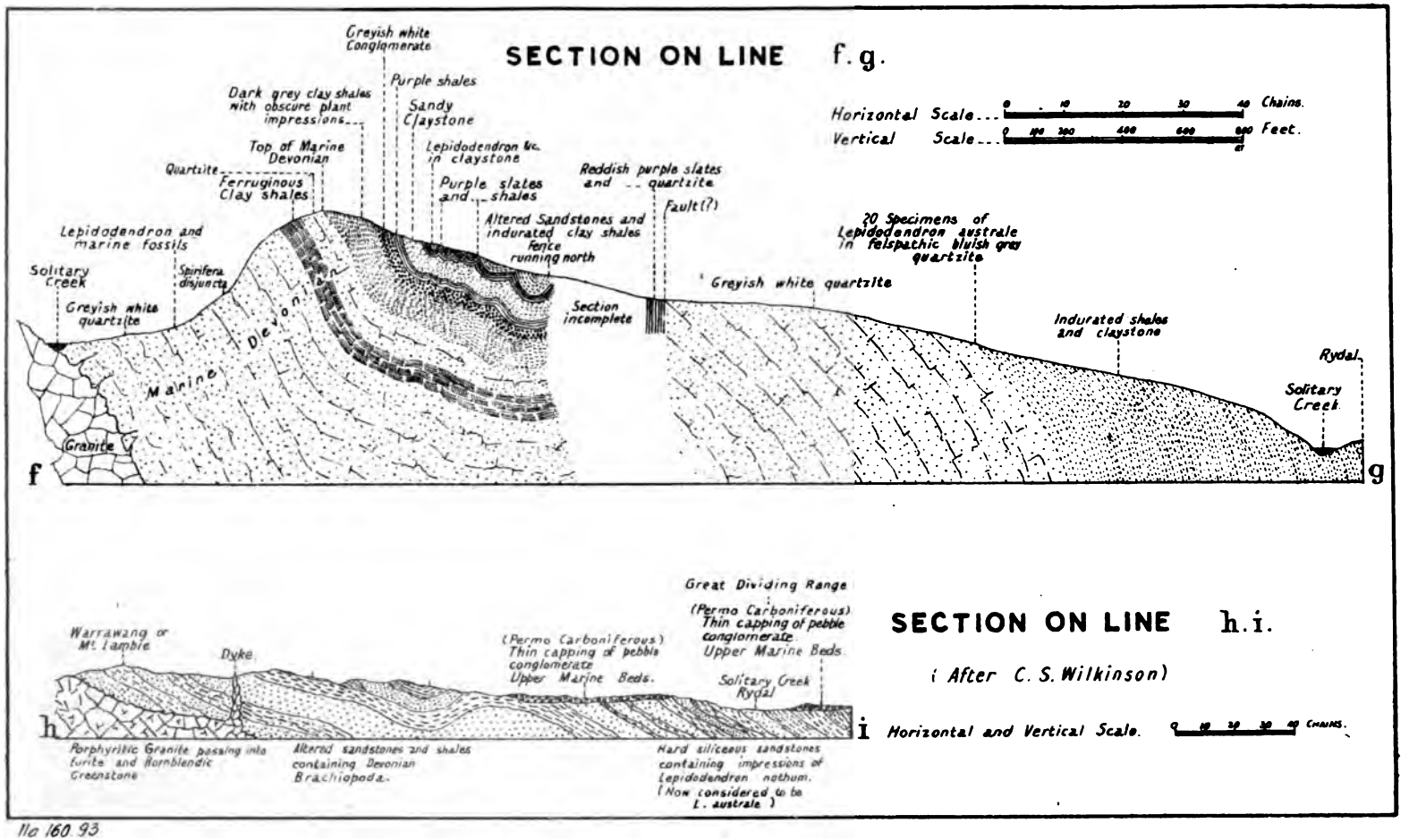
Horizontal Sketch Sections through the Mount Lambie District—to accompany Sketch Map, Plate XVIII.

Section *f*—*g*, by Messrs. David and Pittman.

Section *h*—*i*, after the late Mr. C. S. Wilkinson.

Hor. scale—20 chains = 1 inch.

Vert. scale—400 ft. = 1 inch.



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